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40 Graphics cards
Get the right graphics card for your needs, and you'll be able to play all of the latest games at the resolution of your choice. Since our last graphics card megatest, AMD has replaced its Radeon 200-series with the 300-series, and introduced its Fury cards with high-bandwidth memory (HBM). Meanwhile, Nvidia has filled out its Maxwell range at both the top and bottom of the pack, releasing both the GeForce GTX 950 and the GTX 980 Ti.

The result is a complete reshuffling of the whole GPU pack, with new technology sitting among rebranded older technology. What's more, the recent crash in the price of 2,560 x 1,440 and 4K monitors means that many PC gamers are now demanding more GPU power than beforehand. If you're thinking of making the push to a higher resolution, or if you just want to play the latest games at 1080p, this Labs test will tell you exactly which graphics card you need.

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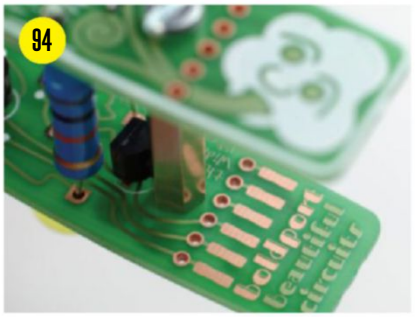

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BEN HARDWIDGE / FROM THE EDITOR

APPEARANCES MATTER

There's nothing wrong with paying more for a product just because it looks good, argues Ben Hardwidge

I'd decided which mountain bike I wanted – it was entry-level, but it had a lovely blue and black colour scheme. I talked to the manager of the shop who then kindly offered me 15 per cent off the price of any of the bikes. 'You could effectively get the next model up for the same price as the entry-level one,' she said, thinking that would be a great deal. But I was then left in a quandary, because the next model up was red and black, and to me, it didn't look as attractive.

I felt ashamed for caring so much about something so shallow. It was a mountain bike – it was only going to get scratched and covered in mud. Why did the colours matter? But they did matter. When I spend a significant amount of cash on a product, I don't just want the best performance, I also want to be able to look lovingly at it and feel like I've bought something wonderful.

Likewise, when I looked at Asus' forthcoming new G-Sync ROG monitors with IPS panels, I was instantly grabbed by the spec. I want to upgrade my monitor soon, and the key factors for me are G-Sync, an IPS panel and a higher resolution than 1080p – currently, there's only one Acer monitor in that category, but Asus' new ROG displays look set to add some much-needed competition. There's just one problem: both the Asus displays and the Acer one have red LED details. They're not going to match the blue and black colour scheme of my water-cooled rig, with its pipes full of Mayhems Blueberry coolant.

Again, I hate the fact that this seems to be important to me now. I could just buy the best kit that suits my needs, but now there's a little niggly voice telling me I can't buy computer kit if I don't like the look of it, or if it doesn't match the rest of my system's colours. I'm similarly annoyed by the lack of blue Corsair Vengeance Pro memory that runs at high frequencies – all the best kits are red or gold. On a side note, is it just me who doesn't really like red and black on computer components? It seems to be the default colour scheme for enthusiast kit for some reason.

> Is it just me who doesn't really like red and black on computer components?

This obsession with appearance and colour appears to be new. I certainly didn't worry about how my PC looked 15 years ago. I just bought the cheapest beige case I could find, filled it with brown and green PCBs, and didn't even bother tidying the cables – the whole lot was done in no time. My PCs looked terrible, but I didn't care – they could play games and that's all that mattered. Now, however, I spend hours building a PC, carefully fitting water-cooling gear and tidying it immaculately. The end result is a computer that's a pleasure to switch on every day – I look at it with pride. So much work has gone into it that I feel I can't now ruin the setup with products that don't match.

But all these feelings conflict with my inner, down-to-earth PC user – the guy who used to look down on Apple products because they emphasised looks over performance and flexibility. But looks *are* important, and there's nothing wrong with paying more for a product just because it looks better than a cheaper one. As such, I decided to buy the next bike up from the red and black model, which had a black and green colour scheme I liked. Here's hoping I start to see more shades of blue in enthusiast PC kit too. CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk @custompcmag

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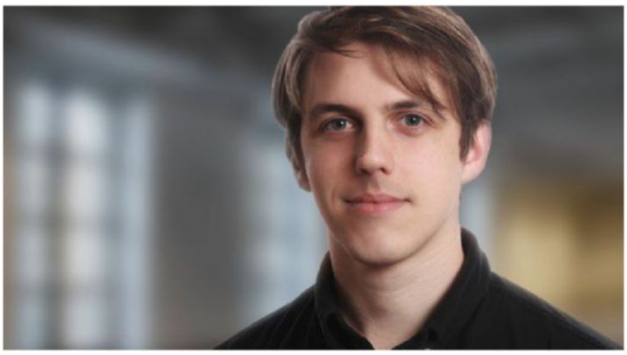

RICHARD SWINBURNE / VIEW FROM TAIWAN

A PEEK AT NVIDIA PASCAL

Richard Swinburne delves into the rumour mill to see what Nvidia's next-gen GPUs could offer us

As the **CPC** Labs team squeeze every last frame per second out the current crop of GPUs (see p40), I've dug around to discover what Nvidia's next-generation Pascal GPUs might offer next year. For starters, after three long years of 28nm GPUs, Pascal will be Nvidia's first die-shrink to 16nm, courtesy of Taiwanese chip maker TSMC. There was briefly talk of using Samsung's 14nm facilities, but reports of yield issues forced Nvidia back to long-time partner TSMC.

Nvidia GP100 and GP104 test chips have already been seen on shipping manifests from TSMC to Nvidia, and people are speculating about a launch in the second quarter of 2016. Analysts expect to see around 4,000 stream processors in the biggest GP100 chip – up from the current 2,816 in GM100 (GTX 980 Ti and Titan X). However, the current speculation is that Nvidia will focus on optimisations for DirectX 12 at its front end, rather than make significant changes to its shader technology.

Use of the latest memory tech – second-generation HBM (HBM2) – has been confirmed too. First-generation HBM from SK Hynix has already premiered in AMD's Radeon Fury cards, offering massive data bandwidth over GDDR5, but with a limited maximum capacity of only 4GB. Like the Fury cards, Pascal cards with HBM2 could be physically tiny too – great news for compact rigs.

Starting from the first quarter of next year, HBM2 from both Samsung and SK Hynix will not only improve bandwidth even further, but also increase maximum capacity to a plentiful 32GB. You could expect to see around 8GB of HBM2 on consumer graphics cards, and up to 16GB on the next Titan.

> Like Fury cards, Pascal cards with HBM2 could be physically tiny

HBM2 is likely to only be found on Nvidia's high-end GPUs – certainly GP100 and likely GP104, but GDDR5X will probably be used on the new mid-range and lower-end GPUs. GDDR5 has been stuck at around 7000MHz (effective) for several years now, but Micron has recently proposed a revised standard it calls GDDR5X, which increases the data-fetch from eight to 16, doubling the effective data-rate at the same frequency.

Micron says the first-generation GDDR5X will offer effective speeds of up to 12000MHz (a 71 per cent boost over GDDR5), with a launch towards the end of 2016, which gives us an insight into the mid-range graphics card launch window.

The reason for an evolution of GDDR5 rather than going top-to-bottom on HBM2 is because HBM-style memory is difficult to make, so demand is expected to outstrip supply through 2016, meaning the cost will remain high. A graphics chip has to be designed for either HBM2 or GDDR technology early on, so this decision has to be made by Nvidia, rather than graphics card partners.

Earlier this year Nvidia also confirmed its NVLink tech. Primarily targeting its Tesla-series chips so that they can be paired with next-gen, NVLink-infused IBM server chips, this high-speed interconnect offers lower latency and increased bandwidth compared with PCI-E 3 (up to 80GB/sec vs 16GB/sec). However, since Nvidia no longer makes PC motherboard chipsets, Pascal gaming graphics cards will still use PCI-E 3. The only possible speculated use for NVLink in Pascal is an upgraded SLI bridge connection, but it's unclear how the physical connector could change, as active data switches would need to be used for 3-way or 4-way SLI. CPC

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

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Letters

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Antistatic wrist slap

After reading issue 147 of **CPC**, I just had to reply on the subject of antistatic wrist straps. They normally incorporate a high-value resistor in the circuit of around one mega-ohm. They can't be checked for continuity with a torch or similar, but would require an ohm-meter.

PAUL JONES

Checking an antistatic wrist strap for continuity requires an ohm meter

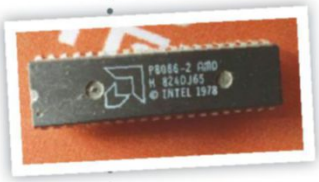
In Issue 147, Bob Stimpson was concerned about the fact that some of the antistatic wrist straps he purchased weren't connected between the crocodile clip and the earth/ground plate on the wrist strap, when tested for continuity. Having worked in electronics for over 40 years I can assure him that there's almost certainly nothing wrong with his wrist straps – if he has a multimeter he should check them using the high ohms range. In fact, for electrical safety, such straps should have a resistance of about one million ohms in series between the ends, *not* a low resistance!

This relatively high value is more than enough to discharge any static charge that's built up on any component/circuitboard safely, when it's handled. Way more importantly, the high resistance is there to protect the wearer from electric shock should they accidentally make contact with any high-voltage circuitry (which is admittedly unlikely when building PCs) – it limits the current that may flow through the wearer's body to a safe level.

There are indeed some antistatic wrist straps that are low-resistance along the whole of cable, but they either plug into an antistatic bench mat, which has the high resistance built into it before being grounded, or they plug into a purpose-made box on the

YOUR OLDEST PC HARDWARE

While looking through the silicon graveyard in his filing cabinet this week, Ben Hardwidge found his very first PC CPU, an 8MHz 8086 (pictured).



We shared the picture on Facebook and Twitter, and asked what historic tech artefacts you had lurking at home, and for your first PC memories. Here are some of the highlights.

SUSAN CHENNELLS STURDY: An AMD K7, Slot A.

PAUL ROBERTS: An Intel Pentium 200MHz MMX still in a working PC. Unfortunately, I don't have my first CPU anymore, an Intel DX4-100.

LEX BOGART: My first PC was a Pentium 100MHz running Windows 3.1. I still have the CPU and the motherboard.

SEBASTIAN ASHWOOD: Mine was a 486 DX2 6MHz running Windows 95. Wow, I can still remember all the BSODs LOL.

CARL DONE: A Socket 423 Willamette Pentium 4 with RDRAM. I paid Dixons way too much for it, and the bloody thing was soon obsolete when new memory came out. Rambus was supposed to be the future – I got savvy after that!

CASEY POWELL: An ATI HD 3870 X2. I don't use it but it's still cool to have.

NICK DEDMAN: I've got a 386SX 40MHz and the motherboard it's soldered onto somewhere.

NICK SWARFEGA: I still have my 287 math processor, but sadly I don't think I have the CPU itself.

MICHEL EXEL also posted this photo of his old box of CPUs, in which we can see some Athlon XPs, several Pentium IIIs and Celerons, a Pentium MMX, a Socket 423 Pentium 4 and some Socket 478 Pentium 4s. We're wondering what Socket 7 chip is next to the Pentium MMX chip though!

ROB FURMAN: I'm not sure what this is – I found the machine while working for someone. People have told me not to chop it for a retro gaming case.

Ben replies: That's a 286 CPU from 1984, Rob. It's not particularly valuable, but it's a cool piece of computing history!

Got some cool old PC hardware at home to show us? Take a photo and send it to us.

> Rambus was supposed to be the future – I got savvy after that!

workbench that contains the current limiting resistance.
SARAH BAILEY

Skylake supply woes

Having read a great review in your magazine for the PC Specialist Hailstorm GT, I recently tried to order one. Unfortunately, I was informed that PC Specialist had removed this PC from its line-up due to shortages of Skylake processors. I asked for an alternative and similarly priced option, and was provided with the same spec (with the same CPU), with a different case for over £130 more. While this PC still seems like a good deal, I'm concerned that PC manufacturers are creating offers for limited periods to pull in potential customers. Would your experts still consider the PC so highly considering the higher price tag, and is this a common issue that's worth your magazine investigating further?
ADRIAN HUNT

Short supply of Skylake CPUs resulted in PC Specialist's Hailstorm GT being temporarily removed from sale

Ben: Sorry to hear about your problems getting hold of a PC Specialist Hailstorm GT. As a general rule, we expect a PC system that's submitted to us for review to be available to our readers for the duration of the review issue's on sale period, as the bare minimum.

We've been in touch with PC Specialist to ask about the situation, which the company puts down to 'global constraint on the enthusiast K-series of Skylake CPUs', a subject that Scan's James Gorbold also discusses in his column on p114. Basically, the stock of Skylake K-series chips is very thin, which in turn means it's hard for retailers and system builders to supply them, and that the prices are also increasing.

We've certainly seen the retail price of the Core i7-6700K rocket since we first reviewed it a few months ago.

PC Specialist says that, as a result, it didn't feel comfortable taking pre-orders for the CPUs until it received firm ETAs for new stock, so it pulled the CPUs temporarily from its site. This had the knock-on effect of meaning that the Hailstorm GT as reviewed was unavailable for that time. PC Specialist says that the stock situation seems to be improving, though, with the Core i5-6600K chips now being back in stock, and Core i7-6700K stock expected shortly.

To answer your question, the same PC for £130 more still isn't a bad spec for the money – the original Hailstorm GT was something of a bargain – but we also understand your frustration, as that's a significant price hike. PC Specialist is no longer selling the Hailstorm GT as reviewed, and we've now removed it from our Elite list. CPC

Twitter highlights

Follow us on Twitter at @CustomPCmag

Lincoln_Ess I need a new sound card – what issue did you review them?
Ben: Check out p28 where we look at three of Asus' new Strix sound cards!

ourmanontheM62 Antony Leather appears to be unaware that flow is proportional to the fourth power of radius on p100 of the latest mag.
Antony: You're correct, thanks for pointing that out! I actually meant that the impact on cooling performance (the CPU and GPU temperatures) when using smaller tubing is negligible, as has been widely proven in the water-cooling community. For example, water-cooling expert Cathar showed that going from 13mm to 8mm tubing results in less than 1°C of difference in CPU temperature. Likewise, you can reduce the voltage on your typical pump from 12V to 5V or 7V and see little or no change, despite the drop in flow rate and pressure.

Southern_Trax Great mag this month – got me through Gatwick departures at silly-o'clock.
Ben: Glad to be of service!

rich_houghton I'm like a pig in muck right now. Perfect Saturday fun #newGPU #newCase

linuxnewbie Hi, Can you recommend any particular size of heatshrink for making your own PC braided cables please? Thank you.
Antony: It all depends on the size of cables you're aiming to cover, and indeed the thickness of the braiding. Your best bet it to measure the diameter of the braid you'll be using, and then buy heatshrink that will be able to pass over this braid before you heat it.

For example, Cablemodder's sleeved wires measure around 2.3mm in diameter, so your heatshrink needs to be in the region of 2.5-3mm.

WHEN'S THE NEXT MAG COMING OUT?
Issue 149 of **Custom PC**, complete with our annual mince pie megatest, will be on sale on Thursday, 10 December, with subscribers receiving it a few days beforehand.

Send your feedback and correspondence to letters@custompcmag.org.uk

TRACY KING / SCEPTICAL ANALYSIS

GAMIFYING CYBER SECURITY

Tracy King smashes some Minecraft-style blocks in the name of cyber security

Your country needs you! The UK government and some private companies, including defence contractors, have identified a skills gap for 'cyber security' and have launched some online games to test your elite skills, and possibly give you a job being Simon Pegg in the Mission Impossible films.

The project is called Cyber Security Challenge UK and its logo looks like it was made in WordArt in 2003, which is mildly discomfiting for a national security recruitment project, but let's not judge the website too harshly. Oh, it has 'page under development' if you click on 'Meet The Team'. Well, elsewhere there's some information, including a 'Women In Cyber' page, which has testimonials from two – count 'em, two – women who have used the scheme. One of them, Ese Oduyoye, was the only woman in 42 finalists in the March 2015 Cyber Security Challenge finals.

Criticisms aside, the March finals looked pretty cool. The finalists were subject to a fake terrorist attack by hackers on board HMS Belfast. They had to regain control of the ship and possibly do some stunt rolls while a countdown clock loomed in the background. Add lasertag and I would happily spend an afternoon doing that, whether or not I got the job at the end. The winners genuinely do get career opportunities, and the gamified format was successful enough for SCS UK to launch the new online versions, called Play on Demand.

SCS UK is on record saying 'a lot of people who are very good at cyber security are also gamers', which doesn't mean gamers are de facto good at cyber security, but does mean it's a democratic way of reaching more diverse potential candidates, rather than the historically limited 'go and hang around in the student bars at Oxbridge in a mysterious overcoat' method.

I signed up for Play on Demand. There's a terrible 'virtual skyscraper' called Cyphinx that had no other players in it, so I used the main site instead. Not having many of the relevant skills or ambitions, I played for fun rather than as an actual entrant, and was given a list of game categories. I picked Forensic Analysis (Easy), and oh my god, it's actual Minecraft.

> I picked Forensic Analysis, and oh my god, it's actual Minecraft

It's immediately great; there are flag-capturing challenges at three difficulty levels and clues everywhere. Playing with actual stakes involved feels a little sinister; if I were genuinely interested in a career in cyber security I might have been a little panicked at some of the difficult levels. As it was, I just smashed up blocks willy-nilly like a toddler.

I then tried the Policy game called The Enemy Within (sounds familiar). Alas, there was no alien invasion; it's a quiz. The zip file I downloaded contained a readme file that I didn't read (automatic fail?) and a PowerPoint file in which you have to poke around to find test answers. It isn't easy, and you may need to download a few free tools, but I loved the challenge.

Sadly, the website is as buggy as it is ugly, and after a while, I became frustrated by pages not loading properly, and refused to use the patronising virtual interface (which doesn't work in Chrome anyway). But despite that, I can see the value. Minecraft aside, it isn't likely to appeal to the majority of gamers, but if this is the new standard for filling a skills gap, I'm all for it. CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdoll

Incoming

We take a look at the latest newly announced products

Roccat launches new Kova

Gaming peripheral maker Roccat is releasing a new Kova gaming mouse, inspired by the design of the original Kova[+] gaming mouse it brought out back in 2010. The new Kova has an ambidextrous design and a 3,500dpi Pro-Optic R6 sensor. What's more, Roccat says that in the unlikely event that 3,500dpi isn't sensitive enough for you, the Kova's 32-bit ARM microcontroller can enable an Overdrive mode, which effectively doubles the resolution to 7,000dpi.

Meanwhile, the Kova's lighting system offers a choice of 16.8 million colours, and Roccat's Easy-Shift[+] system effectively enables up to 22 button functions. The Kova is scheduled to be available from 17 November, with a recommended price of €60 (around £43).

NZXT sees the light

NZXT is branching out into PC lighting with its new HUE+ kit ,which goes beyond the usual LED strips and includes smart features 'capable of reacting to changes in system conditions', including CPU and GPU temperatures, and even gaming frame rates. You can also fully customise your PC's illumination with the company's CAM software. The package includes four LED strips and four extension cables of different lengths, but you can also add extra LED strips to it. As with BitFenix's recent LED strips, the strips supplied with the HUE+ feature strong magnets to pin them to cases made from magnetic material, or you can use the supplied 3M tape. The NZXT HUE+ kit is available now from UK etailers **www.overclockers.co.uk** and **www.scan.co.uk** for £40 inc VAT.

EK water-cools Intel SSD

We've seen waterblocks for CPUs, GPUs, memory, motherboard chipsets and even hard drives, but water-cooling specialist EK has just announced a waterblock to cool Intel's latest 750-series SSDs. EK says its new EK-FC I750 block was designed in cooperation with Intel to match the appearance of the drives' original heatsink shroud as closely as possible, covering the entire PCB.

Intel specifies a maximum operating temperature of 55°C for the drives when active, so they do get hot, but not as hot as a CPU or GPU. Whether you gain much benefit from water-cooling an Intel 750 SSD remains to be seen, but the blocks certainly look good. The blocks are available from **https://shop.ekwb.com** now for €90 (around £65).

Corsair silences mechanical keyboard

If you like the tactile feel of a mechanical keyboard, but find yourself irritated by the constant clickety-clack sound as you hammer the keys then Corsair may have the solution to your woes. The company's new Strafe RGB Silent features Cherry's new MX Silent switches, each of which features a patented internal noise-dampening system that Corsair says reduces bottoming out and spring-back noise, and doesn't simply feature 'O-rings or quick-fix external fittings'. According to Corsair, the noise from the new switches is up to 30 per cent quieter than standard mechanical switches.

The Strafe RGB Silent also features multi-coloured lighting that's customisable on a per-key level, with a number of effects available. The Strafe RGB Silent is available from **www.scan.co.uk** for £135 inc VAT now, and we're hoping to get a review sample for our next issue.

Reviews

Our in-depth analysis of the latest PC hardware

Reviewed this month

Alpenföhn Atlas p17 / Samsung SSD 950 Pro 256GB and 512GB p18 / Asus Maximus VIII Impact p20 / In Win 805 p24 / Cooler Master MasterCase Pro 5 p26 / Asus Strix Soar, Raid Pro and Raid DLX p28 / EKWB Predator 240 p30 / Synology DS216play p32 / Custom kit p38

HOW WE TEST
PAGE 34

CPU COOLER

Alpenföhn Atlas / £43 inc VAT

SUPPLIER www.overclockers.co.uk

The Alpenföhn Atlas targets micro-ATX and mini-ITX users, with its low 125mm height giving it compatibility with many small form factor cases. It also claims to have no RAM or compatibility issues. It has a dual tower design, with the aluminium fins fed by five copper heatpipes that pass through the copper baseplate. The entire cooler is nickel-plated for a consistent look and the build quality is high.

For your £43, you also get two seven-blade 92mm PWM fans with 80mm mounting holes. Each fan has a neatly braided cable with a splitter connection, so you can power and control both with one header if necessary. You also get a 12V Molex adaptor with a short, braided black cable and two 7V Molex adaptors for low noise operation. However, these adaptors come with ugly exposed cables.

The entire cooler is nickel-plated for a consistent look and build quality is high

Mounting the Atlas involves fitting a universal metal backplate on all sockets except LGA2011 ones. Attaching the two mounting arms to the motherboard is easy, but getting the cooler onto them, especially inside a chassis, was fiddly. There's a locking bar with pre-attached, spring-loaded screws, which is good, but once you've secured one screw – even a little – the second one is difficult to align.

The supplied fan clips are as fiddly as usual, but they'll be fitted after a few attempts. One fan sits between the towers and another on either the front or rear. Using the rear mount avoids RAM slots on most motherboards, but on LGA2011 systems, both the front and rear positions interfere with RAM slots, so low-profile DIMMs may be necessary. Also, the rear position is so far back that using it may require you to remove your exhaust fan, depending on your case.

At full speed, the Atlas is capable for its size, offering temperatures that aren't too far off an average all-in-one liquid cooler and also better than Noctua's NH-D9L, albeit only by 1°C. The fan noise is noticeably audible with both fans spinning at this speed, however, which is a shame; at 7V, where it's far quieter, the performance falls apart and both our overclocked CPUs hit their thermal limit.

The Atlas is certainly a well-made cooler, but it's difficult to recommend next to Noctua's excellent NH-D9L. The price for both coolers is similar, but Noctua's effort is smaller in every dimension and it can still cope with overclocked, high-end CPUs at low fan speeds.

MATTHEW LAMBERT

/SPECIFICATIONS

Compatibility Intel: LGA775, LGA1366, LGA115x, LGA2011(-v3) AMD: Socket AM3(+), AM2(+), FM2(+), FM1

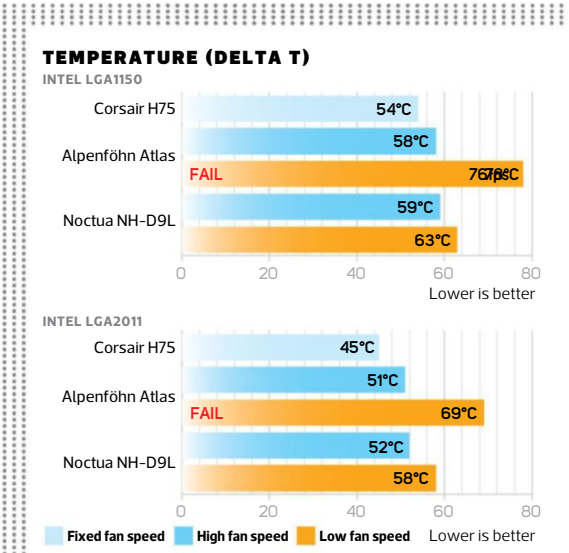
Weight 650g

Materials Copper, aluminium

Size (mm) 105 x 140 x 125 (W x D x H)

Fans 2 x 92mm

Stated noise 8-24.3 dB(A) (per fan)



LGA115x

COOLING 32/40 | DESIGN 24/30 | VALUE 21/30

OVERALL SCORE 77%

LGA2011

COOLING 30/40 | DESIGN 24/30 | VALUE 21/30

OVERALL SCORE 75%

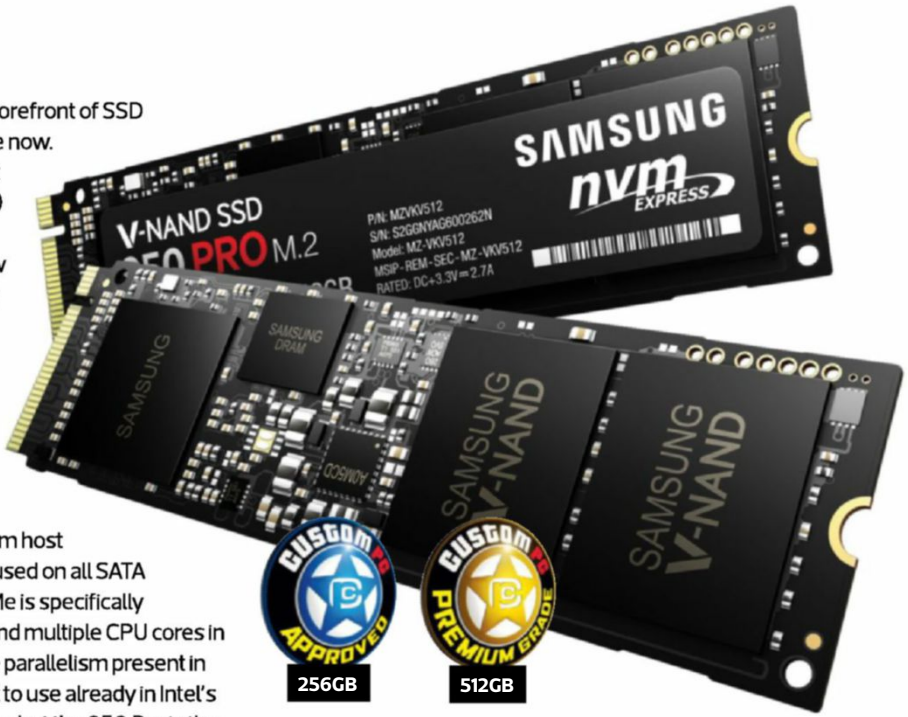
VERDICT

A solid cooler in some regards, but it struggles to cool overclocked CPUs at low fan speeds.

SOLID STATE DRIVE

Samsung SSD 950 Pro / £170 inc VAT (256GB); £320 inc VAT (512GB)

SUPPLIER www.scan.co.uk



Samsung has been at the forefront of SSD technology for some time now. The 840 Evo was the first SSD to feature triple-level cell (TLC) NAND, while the SSD 850 Pro introduced us to 3D NAND. The new SSD 950 Pro, while not introducing any new technologies of its own, does merge a whole host of emerging standards into one tiny but incredibly powerful stick of solid state storage.

NVMe is a protocol that specifies a new means of communication between the system host and the SSD. Unlike AHCI, which is used on all SATA SSDs and modern hard drives, NVMe is specifically designed with NAND flash, PCI-E and multiple CPU cores in mind, aiming to exploit the massive parallelism present in modern systems. We've seen it put to use already in Intel's SSD 750 series, but the 950 Pro is the first consumer M.2 drive to take advantage of it.

NVMe is designed with NAND flash, PCI-E and multiple CPU cores in mind

Samsung technically already has an NVMe M.2 SSD, but it's the OEM SM951 (unlike the 950 Pro, this also has an AHCI version). Physically, the new 950 Pro is very similar to the NVMe SM951.

For instance, both drives use the popular M.2 2280 form factor and the PCI-E bus. Most X99 and Z170 motherboards support this size of M.2 drive and PCI-E storage; however, some of these boards and many laptops (especially older ones) will have SATA-only M.2 slots, so you'll need to check if you're planning an upgrade. Lastly, both drives require four PCI-E 3 lanes to function at full speed and, again, you'll need to check your board's capabilities – if your M.2 slot only supports PCI-E 2, or just two lanes, your speeds will be capped.

The 950 Pro uses Samsung's UBX controller, and pairs it with 512MB of Samsung LPDDR3 for cache and Samsung firmware. So far, it's just like SM951. The difference, then, is the NAND, with Samsung moving away from planar/2D NAND to its 3D NAND tech now known as V-NAND. Specifically, it's using its second-generation, 32-layer dies with a 128Gb capacity.

There's only room for two NAND packages on the 950 Pro, as Samsung has kept the drive single-sided to maintain compatibility and reduce thermal stress.

As such, there are eight dies per package on the 256GB drive, and 16 per package on the 512GB drive. Samsung has also dropped the 128GB capacity seen in the SM951 range, but will introduce a 1TB SSD 950 Pro next year when it rolls out its third-generation, 48-layer 256Gb V-NAND dies.

Despite the new NAND, the 950 Pro's performance isn't much different to that of the SM951. The main differences come from one being a consumer drive and the other an OEM. For example, the 950 Pro has an all-black PCB, which may hold sway with enthusiasts, as it will look much better in almost any build than the bright green SM951.

The main benefit you get, though, is a proper, Samsung-backed warranty of five years. It covers 200 TBW (terabytes written) for the 256GB drive or 400 TBW for the 512GB – that's 33 per cent more TBW than the 850 Pro drives guarantee, although the warranty period is half as long. Either way, it's a very generous offering that should leave you with little doubt about the drive's endurance.

You also get hardware-accelerated encryption with TGC Opal 2.0 support, or at least you will do through a future firmware update. Lastly, Samsung's excellent Magician software has full support for the SSD 950 Pro. This software provides easy firmware updates, monitoring, manual overprovisioning, encryption implementation and secure erase features.

Performance

Before we delve into the performance figures, we need to note that the results for the SSD 850 Pro 1TB are from a different test system to the X99 one we used here. We no longer had access to this sample at the time of testing, but wanted to include it anyway, given that it's essentially the fastest SATA 6Gbps SSD around.

CrystalDiskMark is a good tool for showing us maximum performance, and the SSD 950 Pro doesn't disappoint. We

/SPECIFICATIONS

Interface M.2 4x PCI-E 3 (32Gb/sec)

Nominal capacity 256GB, 512GB

Formatted capacity 238.47GB, 476.94GB

Controller Samsung UBX

Cache Samsung 512MB LPDDR3

Memory Samsung 128Gb 32-layer V-NAND MLC

Warranty Five years (maximum 110GB/day or 220GB/day host writes)

ELITE
NEW ENTRY
P68

saw sequential read speeds of 2.6GB/sec, dropping slightly to around 2.3GB/sec for the 256GB drive, with both results being pretty close to Intel's 750. When it comes to write speeds, the 512GB drive is faster than Intel's 1.2TB monster, hitting over 1.5GB/sec, and the 256GB is no slouch either, hitting just under 1GB/sec. Meanwhile, the SATA SSD 850 Pro is still a fast SSD, of course, but it's no match for these NVMe ones.

That said, the real-world traces in PCMark 7 suggest that, while the new NVMe drives do have an advantage for everyday use, it's much smaller than the CrystalDiskMark results suggest. The SSD 950 Pro SSDs lead their SATA-based sibling by 8-9 per cent in this test, and also have a very small lead over Intel too.

The PCMark 8 traces, meanwhile, show no meaningful difference for general office tasks. Even game loading doesn't seem to benefit much from the increased speed, with the 950 Pro only able to shave one second off the 850 Pro's time. Only the Photoshop Heavy trace shows a significant difference, with all three NVMe drives completing the test around ten seconds faster than the 850 Pro's six-minute time.

Finally, the Iometer tests, which mimic heavy professional drive access patterns with a barrage of reads and writes at a high queue depth, show clear gains. Even the 256GB 950 Pro is more than twice as fast as the 1TB 850 Pro, as the additional PCI-E bandwidth and NVMe's improved ability to deal with multiple CPU threads come into play. With its extra NAND dies, the 512GB drive is over a third faster still. However, victory goes to Intel here, which isn't surprising, as the 750 is very much a professional-level SSD.

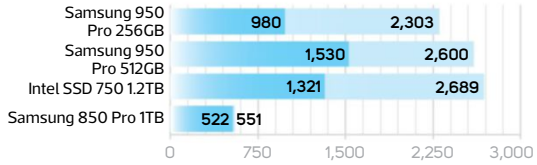
Conclusion

The SSD 950 Pro is hands down the best M.2 SSD around. It matches staggering transfer speeds with an excellent warranty and solid feature set, and it even has an attractive black PCB. It's bound to appeal to enthusiasts who want the best performance, especially those who are also into small form factors PCs, for which M.2 is a perfect match. That said, the cost per gigabyte is massive and the speed advantage will have little real-world impact for most home users compared with using a standard SATA SSD, which offers much better value for money.

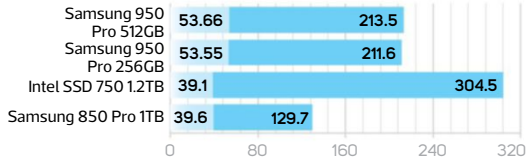
MATTHEW LAMBERT

CRYSTALDISKMARK

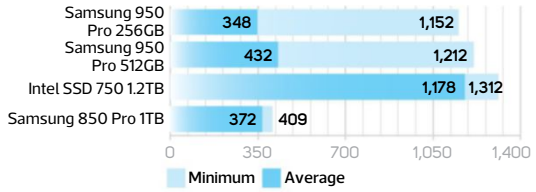
Sequential read/write (MB/sec)



4KB random read/write (MB/sec)

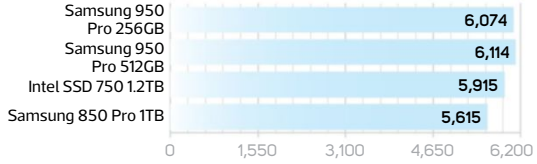


4KB 32-queue-depth random read/write (MB/sec)



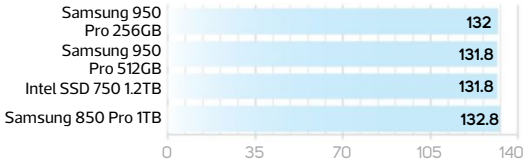
PCMARK 7

Secondary storage

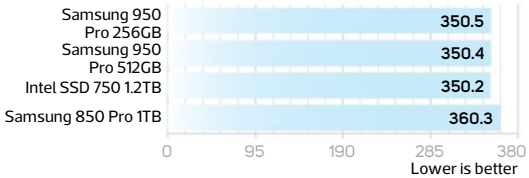


PCMARK 8

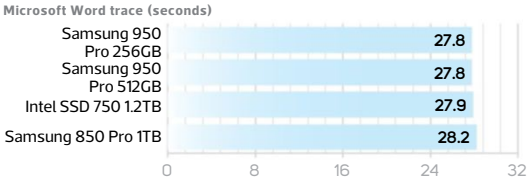
Battlefield 3 trace (seconds)



Photoshop heavy trace (seconds)

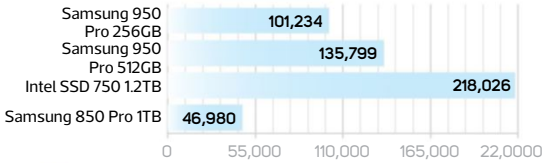


Microsoft Word trace (seconds)



IOMETER

Mixed workloads average score (IOPS)



256GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
47/50	10/20	20/30	77%

512GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
48/50	11/20	21/30	80%

VERDICT

An awesome show of SSD strength from Samsung and a great choice for high-end small form factor builds, but for most home users, a better-value SATA SSD is still fine.

MINI-ITX MOTHERBOARD

Asus Maximus VIII Impact / £186 inc VAT

SUPPLIER www.scan.co.uk

Asus revolutionised the high-end small form factor PC when it launched its first Maximus Impact board. It sported a VRM daughterboard, loads of tweaking and overclocking tools, a discrete proprietary sound, and all the bells and whistles usually offered by high-end ROG motherboards, except expansion slots. It was a big hit with its target market, and the Maximus VIII Impact now brings the Impact series into the Z170 Skylake world.

This time, Asus has moved the power, reset and clear-CMOS buttons from the PCB to the rear I/O panel. The result is a board that visually looks slightly less feature-packed, but the features are still there, as is an LED POST code display and USB BIOS Flashback button.

The PCB also sports the familiar VRM daughterboard, which has heatsinks on both sides and provides additional power phases. The Maximus VIII Impact offers a total of ten power phases, with six for the CPU and two apiece for the integrated GPU and DRAM. Comparatively, Asus' cheaper Z170i Pro Gaming only has four power phases, although that didn't seem to limit its overclocking headroom, as it managed a respectable 4.8GHz with our Core i7-6770K last month.

M.2 has been ditched in favour of U.2

Meanwhile, the sound card is based on Realtek's ALC1150 audio codec, but there's a HyperStream ESS9023 DAC, a dedicated clock, electronic shielding and Nichicon capacitors. You also get a more advanced Asus software suite compared with your average Realtek on-board audio system too, although the sound card itself is rather chunky – thankfully, it doesn't obstruct any of the PCB's components, although it remains to be seen if any of the inevitable third-party, full-cover waterblocks from the likes of Bitspower or EK will cover the PCB as extensively as previous models.

As usual, you get four SATA 6Gbps ports, which are located to the left of the DIMM slots, which may cause issues with cable routing, but the location of these parts has always been the same with the Impact motherboards. The PCB is otherwise fairly clear and there's enough room around the CPU socket and above the sound card to use an all-in-one liquid cooler too.

In terms of new connections, there are USB 3.1 Type-A and Type-C ports courtesy of Intel's Alpine Ridge controller, but M.2 has been ditched in favour of U.2, meaning you'll be able to hook it up to one of Intel's 2.5in 750 SSDs, but you won't be able to use any of the speedy M.2 SSDs available, including Samsung's 950 Pro (see p18). That's a great shame, as Samsung's 950 Pro is a corker and also cheaper than Intel's 2.5in SSD 750. Products making use of U.2 are fairly thin on the ground but there are plenty of M.2 devices in a range of speeds and prices.

We spoke to Asus about this decision, and the company told us that U.2 does have some advantages. The drive isn't strapped to the PCB as with M.2 drives, for example, so you're less likely to suffer from the drive overheating and throttling, although with the latest SSDs drawing a paltry amount of power, that's perhaps unlikely.

In any event, Asus seems confident in its decision and U.2 may well become popular next year. For now, though, if you've set your sights set on a mini-ITX Skylake rig using a Samsung 950 Pro, you can consider Asus' Z170i Pro Gaming instead, or just use a standard SATA SSD until U.2 drives become more widely available.

In the box, you also get a magnetic desktop Wi-Fi aerial that hooks up to the two 802.11ac antenna outputs on the back. There's also an extended fan hub, which allows you to add up to four 3/4-pin fans and control them from the EFI, as well as two thermal probe headers with wine probe included too.

Performance

At stock speed, The Impact's performance was a little lacklustre, with the cheaper Z170i Pro Gaming managing a slightly higher score in our RealBench 2015 tests. The Impact was a tad slower in Total War: Attila too and in the

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 2 slots: max 32GB DDR3 (up to 4133MHz)

Expansion slots One 16x PCI-E 3

Sound Asus SupremeFX Impact III

Networking Intel Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Overclocking Base clock 40–650MHz, CPU multiplier 8–83x; max voltages, CPU 1.7V, RAM 2V

Ports 4 x SATA 6Gbps (Z170), 1 x SATA Express, 1 x U.2, 4 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x LAN, 2 x Wi-Fi antenna outputs, 3 x surround audio out, line in, mic, 1 x HDMI

Dimensions (mm) 170 x 170

HOW WE TEST
PAGE 34

1 **The sound card has a Realtek codec, but uses a HyperStream ESS9023 DAC**

2 **The familiar Impact VRM daughterboard provides additional power phases**

3 **Two antenna outputs are provided for the 802.11ac Wi-Fi adaptor**

SATA 6Gbps tests, where the write speed was around 10MB/sec slower than the Z170i Pro Gaming. The Impact's audio production was also slightly better in RightMark's Audio Analyzer tests, though, with the Impact offering a superior signal-to-noise ratio and dynamic range, as well as lower total harmonic distortion, although the differences were slight.

Overclocking a ROG motherboard is usually a pleasure, and the Impact was no exception. The EFI is clean and lag-free and all the settings you need are clumped together for easy access. We first aimed for 4.8GHz using a 1.4V vcore, which was fine, so we tried for 4.9GHz. At the latter frequency, RealBench initially failed halfway through, but simply setting loadline calibration to maximum solved this problem. You'll need at least 1.4V to hit this frequency though; dropping down to 1.38V resulted in instability. Even so, 4.9GHz is the absolute best we've seen from our CPU, so the Impact is actually better than the vast majority of boards we've tested – quite an achievement.

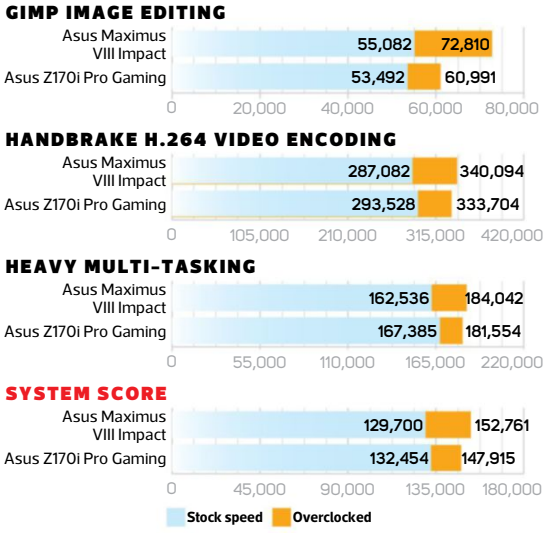
Conclusion

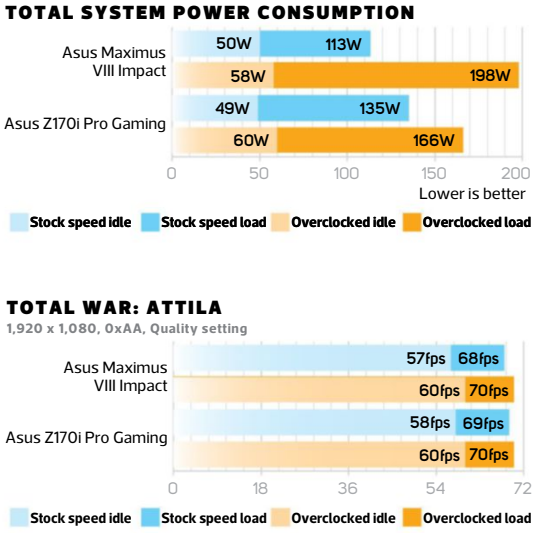
The Maximus VIII Impact is very probably the best mini-ITX motherboard we're likely to see for the Z170 chipset, but it isn't quite as unequivocally awesome or as broadly appealing as its predecessors. The lack of an M.2 port is a shame, as many potential owners are likely to want to pair it with the likes of Samsung's 950 Pro, especially to save space in mini-ITX systems.

However, layout is generally excellent – you get all the other latest connection standards, 802.11ac Wi-Fi, plenty of overclocking headroom, great tweaking tools and most likely a decent choice of waterblocks as well. You inevitably pay a hefty price for the end result, but if you want the ultimate mini-ITX Skylake board, the Maximus VIII Impact is the one to buy. For everyone else, though, Asus' cheaper Z170i Pro Gaming is still a fine board, and it has the benefit of M.2 support as well.

ANTONY LEATHER

CPC MEDIA REALBENCH 2007





SPEED **37/40** | FEATURES **25/30**

VALUE **22/30**

OVERALL SCORE **84%**

VERDICT

An excellent overclocker that's loaded with features, although it's let down by the lack of an M.2 port, and it has a high asking price.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc 100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

PC Specialist recommends Windows

Windows 10

Performance without compromise

Spectre Lite

- AMD FX-4300
- ASUS® M5A97 R2.0
- 8GB Hyper-X FURY RAM
- 2GB NVIDIA® GeForce® GTX 950
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- **Windows 10**
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- ASUS® Maximus VIII Hero
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- 3 Years Standard Warranty

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- ASUS® MAXIMUS VIII Hero
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ATX CASE

In Win 805 / £125 inc VAT

SUPPLIER www.overclockers.co.uk

We have to hand it to In Win – the company has made one of the biggest turnarounds we've seen in the PC industry, leaving its average, plastic-laden products behind and producing some of the best-looking cases we've ever seen. Its new 805 is also a slightly more reasonably priced case than the gorgeous, but eye-wateringly expensive 909. Like the 909, the 805 is made from aluminium and sports the characteristic tempered glass side panel that made its siblings so distinctive, yet it costs £130 inc VAT – less than half the price of the 909.

The heavy glass panel is held in place with thumbscrews and is easily removable, while the case itself can house full-sized ATX motherboards and is the first case we've seen to include a USB 3.1 Type-C connector on the front panel, in addition to the usual ports and buttons. As you'd expect on a case that has a strong aesthetic weighting, the 805 lacks external 5.25in bays, so if you need to use a bay reservoir, fan controller or optical drive, you may need to look elsewhere. With no front-facing drive bays, though, In Win has been able to create a front panel with an attractive hexagonal pattern, which looks great when illuminated from behind and also acts as a porous panel to allow air into the chassis.

The hexagonal pattern looks great when illuminated from behind

That said, airflow is generally a little restricted in the 805 – the main way for air to enter the case is from below, where there are two 120mm fan mounts with dust filters but, out of the box, these mounts are obstructed by drive mounts. On the plus side, In Win has made full use of the two front panel fan mounts, with space for either 120mm or 140mm fans. The company makes a big point of stating radiator compatibility too – there's space for double 120mm/140mm-fan full-height models in the front of the case and, with 320mm of clearance between the front and rear sections, even fairly long graphics cards will leave enough room for half-height radiators in this location.

There's space for a 120mm radiator in the rear fan mount too, albeit with a 35mm height limit, and In Win has also included various reservoir mounting points in the motherboard tray – it's a great case for water-cooling setups. It isn't quite as good for air cooling, though, as the case's comparatively slim dimensions – it measures just 200mm wide – mean that CPU coolers are limited to 156mm in height, which rules out many large tower heatsinks.

Meanwhile, there are plenty of internal drive bays, with three dedicated 2.5in mounts behind the motherboard tray and a further one located above the main drive mount in the main chamber. The latter can house either two 3.5in or 2.5in drives, so there's enough scope for plenty of mixed storage. The main drive mount can also be moved up and down the front fan mounts, so you could raise it up to clear the base for water-cooling gear or remove it entirely.

There are plenty of cable-routing holes too; however, disappointingly, they aren't lined with rubber grommets, so they can look a little unsightly – you'll need to spend some time tidying your PSU cables here, but there's enough room behind the motherboard tray to make this job relatively painless. Overall, it's easy to work with this chassis, and there are plenty of additions that make installing hardware and cooling systems easy. The final pieces of aesthetic wizardry are an illuminated In Win logo in the side of the front panel (various colours are available from different models), plus a suction-cup headset holder that works well on the glass panel.

Performance

With only one fan in the case as standard – a 120mm rear exhaust – the 805 isn't geared towards stellar air cooling out of the box. However, the case is very porous in quite a few places, so there's plenty of ventilation, helping the 805 to produce some surprisingly good cooling results for both the CPU and GPU. Our overclocked Core i7-4790K was kept at a chilly delta T of 53°C – the same result as Corsair's 750D Airflow edition and Fractal Design's Define XL R2 on its maximum fan speed, and cooler than NZXT's H440 SE.

However, this result was still mid-table compared with some of the better cases we've seen – SilverStone's Fortress FT05 for example, managed a delta T of 45°C. The GPU delta T of 51°C was a similar story. Again a mid-table result, the 805 was on a par with the Corsair 750D Airflow

/SPECIFICATIONS

Dimensions (mm) 205 x 455 x 476 (W x D x H)

Material Aluminium, tempered glass

Available colours Black

Front panel Power, 1 x USB 3.1 Type-C, 1 x USB 3, 1 x USB 2, stereo, mic

Drive bays 2 x 3.5in/2.5in, 4 x 2.5in

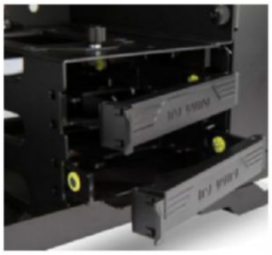
Form factor(s) ATX, micro-ATX, mini-ITX

Cooling 2 x 120mm/140mm front fan mounts (fans not included), 2 x 120mm base fan mounts (fans not included), 1 x 120mm rear fan mount (fan included)

CPU cooler clearance 156mm

Maximum graphics card length 320mm

HOW WE TEST
PAGE 34



1 **The In Win logo is illuminated, with a choice of colours available**

2 **There are plenty of cable-routing holes, although they aren't rubber-lined**

3 **This is the first time we've seen a front panel USB 3.1 Type-C connector**

**Please note, the PSU pictured above is for illustrative purposes. The In Win 805 does not come with a PSU*

Edition and cooler than NZXT's H440 SE. Once again, though, the out-of-the-box cooling was better from cases such as SilverStone's FT05. Unlike the FT05, though, the 805 isn't designed for stunning air cooling, and the temperatures it achieves are still fine for an overclocked rig. The included fan was relatively quiet too, despite shifting enough air to keep the temperatures surprisingly low.

Conclusion

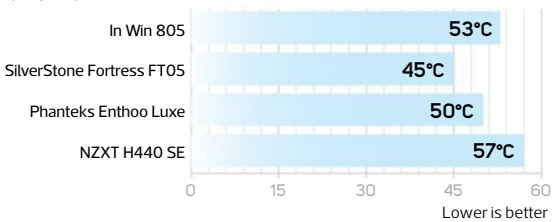
Aesthetically, the In Win 805 isn't quite as jaw-dropping as its more expensive siblings, but it's very good-looking nonetheless. The solid glass side panel looks great, and it also provides a wide view of the interior. The case lacks a PSU cover, though, which is a fly in the ointment, especially as NZXT includes them in its aesthetically focused cases such as the similarly priced H440 SE. These covers do a great job of giving the interior a clean look, so it's a shame you don't get one with the 805, especially as the PSU area is in full view through the window.

Other notable omissions are fan control, cable routing grommets and fan hubs – features that are often included in competing cases. However, the 805 makes up for these omissions with its edgy looks, great design and good cooling (despite only offering one fan as standard), while also maintaining a decent level of water-cooling support.

Achieving this balance isn't easy, and In Win's aluminium cases with tempered glass don't usually offer this level of flexibility either, with the 805 blending outlandish aesthetics with an everyday case that's still sure to turn heads. Best of all, it only costs £130 inc VAT, so it competes well with other ATX cases price-wise too.

ANTONY LEATHER

CPU LOAD DELTA T



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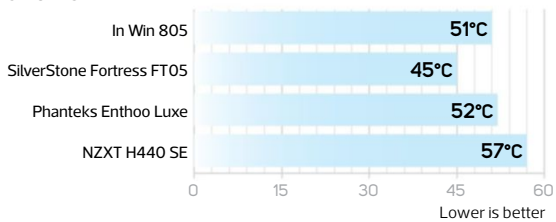


COOLING	FEATURES	OVERALL SCORE
22/25	20/25	86%
DESIGN	**VALUE**	
27/30	17/20	

VERDICT

The 805 is a great-looking case that sports In Win's trademark glass side panel and loads of water-cooling features and, unlike some of its hideously expensive siblings, it has a reasonable price too.

ATX CASE

Cooler Master MasterCase Pro 5 / £110 inc VAT

SUPPLIER www.scan.co.uk

The MasterCase Pro 5, along with its sibling, the MasterCase 5, is one of two chassis used to launch Make It Yours – Cooler Master's company-wide concept that's soon to be applied to a number of its product lines, with a focus on modular components and upgrades.

The MasterCase 5 is the entry-level chassis, along with a series of accessories (five for now, more to come) with which you can upgrade it over time. Meanwhile, the MasterCase Pro essentially comes pre-upgraded for a saving compared with buying the parts separately. Eventually, a top-spec Maker 5 chassis will be offered in a similar vein. The idea is that you can upgrade from one to the other, or to an amalgamation of them by combining accessories as you see fit.

Initial impressions of the Pro 5 are good. The material quality is high, even on the plastic roof and front panels, and the core chassis is solid and sturdy. Up front is a top-to-bottom mesh section that will provide good airflow to the two included 140mm intake fans, which are complemented by a third fan in the rear exhaust mount. The two optical drive covers are meshed too, which is handy, as you can install a third 140mm front fan if you remove the optical drive cage. It's easy to clip out both these covers and the main mesh section, and they double up as dust filters too.

Similarly, the roof has a long mesh section, again backed by filtering material. This can be quickly removed for cleaning by sliding it off, which reveals a 280mm/240mm radiator mounting bracket with elongated mounting struts to support radiators with different spacings. This bracket is one of the accessories sold separately, and it's held in place with four thumbscrews, which will make installing radiators a cinch in this location. The front of the roof also holds the front I/O panel, which is easily accessed and embedded into the area at the front. It has the usual set of connections and a hole suitable for resting a charging mobile device.

Meanwhile, the large clear window on the left panel has a blackout strip along the bottom to help hide PSU cables from view, while leaving the tidier upper chamber in sight.

This side panel is sold separately too. Both side panels use captive thumbscrews and are easily removed.

The PSU itself is slid into place from the back using a thumbscrew-secured bracket. The intake area here is guarded by a slide-out dust filter, meaning the case has the full suite of dust protection – front, top and bottom. The PSU also rests on two foam rails to help quell vibrations.

At the front of the lower cavity is a two-bay drive cage, with the trays offering support for both 3.5in and 2.5in devices. Move up, and you'll find an additional three-bay cage with the optical drive cage secured above it. All three cages are removable, but only the hard drive cages use the clip-and-click system that relies on a vertical stack of mounting holes. This system enables you to adjust the position of the cages with ease – you push them into the holes, and then securing them using their two captive thumbscrews. Both cages are sold separately as accessories if you need more, and the clip-and-click system will also be used for future accessories such as reservoirs and GPU support brackets.

As well as the five 3.5in/2.5 drive mounts, Cooler Master includes two dedicated 2.5in mounts in the form of its slip-and-clip trays, which are again sold separately too. They're fitted to the floor of the upper cavity by default, but you could also move one or both to behind the motherboard tray (or buy two more of your own), as there are mounting points in this location too.

Meanwhile, all the internal cables are sleeved in black and cable routing is very easy. There's lots of space in the lower section and a decent amount of room behind the motherboard tray as well. The cable-routing holes are well placed, suitably sized and the majority have rubber grommets fitted securely too. Finishing it off is a series of three Velcro cable ties, which make cable tidying easier.

In terms of water-cooling support, both the roof and front sections support 280mm and 240mm radiators, although there's only officially room for a slimline one with a single

/SPECIFICATIONS

Dimensions (mm) 235 x 548 x 512 (W x D x H)

Material Steel, plastic

Available colours Dark metallic grey

Weight 10.7kg

Front panel Power, reset, 2 x USB 3, stereo audio, mic

Drive bays 2 x external 5.25in, 5 x internal 3.5in/2.5in, 2 x internal 2.5in (additional cages available separately)

Form factor(s) ATX, micro-ATX, mini-ITX

Cooling 3 x 140mm/120mm front fan mounts (2 x 140mm fans included), 1 x 140mm/120mm rear fan mount (140mm fan included), 2 x 140mm/120mm roof fan mounts, (fans not included)

CPU cooler clearance 190mm

Maximum graphics card length 412mm (296mm with hard drive bracket installed)

Extras Removable dust filters

1 **The hard drive cages use Cooler Master's clip-and-click system**

2 **The cable-routing holes are well placed and suitably sized**

3 **The power supply air-intake area is guarded by a slide-out dust filter**

row of fans in each case, which isn't massive. Further, mounting a 280mm radiator in the front requires the removal of the optical drive cage, and any radiator here will need you to move the low 2.5in cage further into the chassis to make room – a job that's thankfully easy. A 360mm radiator may also fit in the front at a push, although you won't be able to secure all of its mounting points.

Performance

The MasterCase Pro 5 delivers solid cooling results. In its default state, the CPU is a little warm with a delta T of 54°C, but not excessively so, especially as all three fans are quiet at full speed. Removing the hard drive cage from in front of the top intake fan sees the temperature here fall to 51°C too, as more cool air reaches the cooler.

GPU cooling is strong as well, with the Pro 5 nipping at the heels of Corsair's 450D, and bettering a number of other mid-sized towers. After all, the case has very good intake airflow, and that hard drive cage doesn't block the lower 140mm intake anyway, so removing it made no difference to the GPU temperature.

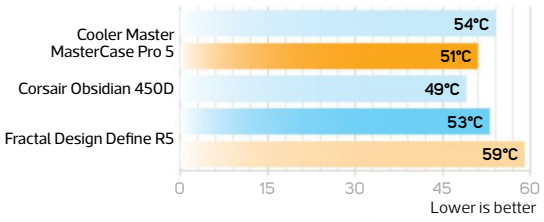
Conclusion

The MasterCase Pro 5 is definitely a great case. It's well made with decent features and good cooling, and the ease of use is a real highlight. That said, at £110 inc VAT, it's pretty steeply priced. It's definitely a better deal than the £90 MasterCase 5, which has no window, radiator bracket, fewer hard drive mounts and one less fan, but compared with the NZXT H440, Fractal Design Define R5 and Corsair Obsidian 450D, for example, it's expensive.

If the price was under £100, we'd be more inclined to give it an outright recommendation, but at this price, features such as a fan controller and better water-cooling support are notably absent. The Make It Yours concept needs to evolve and mature with more accessories before we'll be convinced of the true value of the Pro 5, but it will certainly serve you very well if you can afford it, and it's a positive new direction for Cooler Master.

MATTHEW LAMBERT

CPU LOAD DELTA T



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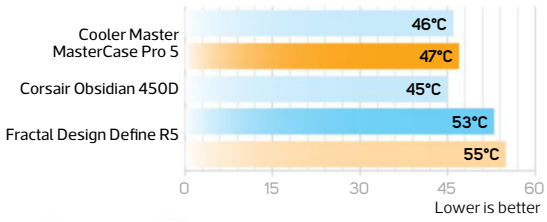


Fixed fan speed | High fan speed | Low fan speed | No hard drive cage

COOLING	FEATURES
24/30	17/20
DESIGN	**VALUE**
27/30	14/20

OVERALL SCORE
82%

VERDICT

A solid case in every regard, and the modular system is a cool idea with some genuinely useful accessories. However, the end result is expensive compared with the competition.

SOUND CARDS

Asus Strix Raid DLX, Raid Pro and Soar

Raid DLX / £137 inc VAT

SUPPLIER www.cclonline.com

●●●●●

Raid Pro / £98 inc VAT

SUPPLIER www.kikatek.com

●●●○○

Soar / £59 inc VAT

SUPPLIER www.cclonline.com

●●●●○

Following on from its graphics cards, Asus has now launched three Strix-branded 7.1-channel PCI-E sound cards. All three of them have dedicated 600ohm headphone amps to power even high-impedance cans, and both the Raid models have a desktop audio station that enables you to control the volume, and switch between headphone and speaker outputs without having to fumble around beneath your desk. Meanwhile, the Soar is identical to the Raid Pro but lacks the external control box.

All three cards use the C-Media CM6632AX audio processor, and can sample up to 24-bit/192KHz. However, the cards have different headphone amps, digital-to-analogue converters (DAC) and analogue-to-digital converters (ADC). The Strix Soar and the Strix Raid Pro use an 8-channel ESS SABRE 9006A DAC for their audio output stage and a Cirrus Logic CS5361 ADC chip for recording audio input, plus a Texas Instruments TPA6120 headphone amplifier. This setup gives the cards a quoted speaker output signal-to-noise ratio (SNR) of 116dB, headphone output SNR of 110dB and a line-in SNR of 110dB.

All three cards use the C-Media CM6632AX audio processor

The Raid DLX has a slightly more upmarket set of components, with an ESS SABRE 9016 DAC, Cirrus Logic CS5381 ADC and Texas Instruments LME49600 headphone amp, giving it a quoted 124dB SNR for line and headphone out, and a 117dB SNR for line-in.

All three cards support up to 7.1 analogue surround sound, with four 3.5mm ports for front, rear, centre and side speakers. The side port also doubles as an optical S/PDIF output, enabling you to connect the Strix cards to your speaker system or amp via a digital input.

There's also a microphone/line input, a headphone output and a 2.5mm box link port. If you have a Strix Raid Pro or Raid DLX, then you can connect all three of these ports to the external audio station box. Meanwhile, the Soar has the box connector port but doesn't include the audio station itself.

The control box itself sits reasonably securely on your desk thanks to a set of rubberised pads. It has microphone and headphone ports, a Kensington security slot and an HDMI-style connector for the proprietary 1.5m breakout cable that connects it to the sound card.

The box is dominated by a satisfyingly chunky volume knob that doubles as a button. A long press mutes all sound, and a short press switches between headphone and speaker mode. There's also a Raid mode button; by default, this switches the knob to controlling your microphone volume. You can also set it up to control surround sound, equaliser or bass boost settings. In practice, we didn't find ourselves using Raid mode very much at all.

/SPECIFICATIONS

Audio processor C-Media CM6632AX

Inputs 3.5mm mic/line in

Outputs 5 x 3.5mm outputs, optical S/PDIF out

Interface 1x PCI-E

Max sample rate 24-bit/192KHz

Extras External control box (Raid models only)

Warranty Three years return to base

Software

Many of the Strix cards' cleverest features are found in the Sonic Studio software control panel, which is clearly designed, but would benefit from larger buttons, text and tick boxes. You can easily switch between headphone, speaker and S/PDIF outputs, adjust volume settings, set the impedance of the headphone amp and enable various audio enhancements, including a graphic equaliser, bass boost and virtual surround sound.

Sonic Studio has various preset audio profiles, including ones for specific Asus headsets and types of game. There isn't much difference between the gaming modes, but the virtual surround sound produced a believable, directionally useful and atmospheric surround experience through stereo headphones in games ranging from Alien: Isolation and Left 4 Dead 2 to Divinity: Original Sin. Gamers can also benefit from Asus' controversial Sonic Radar Pro technology, which converts directional sound generated by the game into visual positional data that you can use to locate enemies and opponents, potentially giving you an advantage in multiplayer combat.

Meanwhile, Sonic Studio's Movie profile also uses virtual surround sound with stereo headphones, and ramps up voice clarity, reverb and audio compression to produce a satisfyingly cinematic experience. However, not all the Sonic Studio profiles are terribly helpful. The Music profile includes virtual surround, bass boost and reverb settings that do no

ELITE
NEW ENTRY
P68

Strix Raid DLX

favours to CD quality audio, although they can add warmth and depth to low-quality YouTube tracks. If you actually want to listen to CD-quality or better audio, then you'll want the Flat preset, which disables all EQ and enhancement settings.

Performance

The Raid DLX did a fine job of reproducing a range of audio tracks, from a high-resolution version of King Crimson's Epitaph, to the busy top end of ColdWorld's Tortured by Solitude and more heavily produced tracks such as Lady Gaga's Telephone, with its emphatic dynamic range compression.

The DLX also stood up well against dedicated audio devices such as Arcam's rPAC entry-level audiophile DAC. We couldn't choose a favourite between them, and the DLX's headphone amp's clear, bright treble characteristics will appeal to a lot of audio enthusiasts. The DLX's main speaker output is a touch bassier than the rPAC's, lending itself to a room-filling sound.

Although the DLX has a higher-quality DAC and headphone amp than the other cards, there isn't very much to choose between the two when it comes to most sound setups. Even on our OPPO PM-1 reference headphones, the DLX sounded a little more detailed on very complex tracks than the Raid Pro, but both sound cards produce high quality sound that will make music enthusiasts happy.

The DLX also really excelled in our Rightmark tests, showing a significant benefit over all the Z170 motherboard audio system we've tested in the SNR and dynamic range tests. The Raid Pro and Soar fared less well in these tests,

Strix Raid Pro/Soar

although the human ear is unlikely to hear the difference on a standard audio setup.

For our recording and communication tests, we used a typical headset microphone. Once again, Sonic Studio's default settings did more harm than good. The default Noise Gate and Perfect Voice settings made voices sound clipped and nasal in their attempt to cut out unwanted background noise and improve clarity – Creative's recent Sound Blaster cards all do a better job here. Disabling those settings produced a surprisingly clean, natural-sounding recording from the Raid DLX though. The Raid Pro also gave us a decent recording, although there was a little more background hiss than from the Strix Raid DLX.

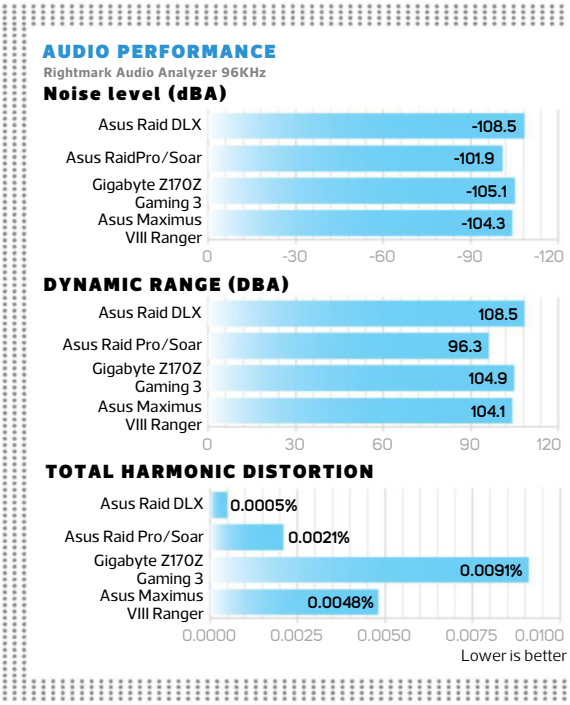
Conclusion

Priced at £135 inc VAT, the Raid DLX puts a bit of a dent in your wallet but is an excellent all-round sound card for a great price, offering superb audio quality. Its virtual surround sound is among the best we've heard, though, and both its headphone and speaker audio quality stand up to some of the best dedicated external amps and AV receivers on the market.

The Raid Pro and Soar, available for £98 and £59 inc VAT respectively, don't use such high-quality components as the DLX, and their noise levels and dynamic range tests in Rightmark don't significantly improve on the best motherboard audio. However, their use of reasonable quality DACs still improves their general audio quality over your average on-board sound chip – if you have a cheaper or older motherboard with standard on-board audio, the Raid Pro or Soar will improve audio quality, and also give you handy features such as virtual surround.

Finally, although the desktop volume control knob is handy, it isn't quite useful enough to justify the hefty price difference between the Raid Pro and Soar cards. The Soar is our choice if you're on a tight budget.

KAT ORPHANIDES



CPU COOLER

EKWB Predator 240i / £170 inc VAT

SUPPLIER www.scan.co.uk / **MODEL NUMBER** 3831109863343

The line between all-in-one liquid coolers and custom kits has suddenly become more blurred recently, thanks to the release of EKWB's Predator coolers. The company is well known for producing some of the best water-cooling components for custom loops, but its new Predator coolers now cram some of this high-performance gear into maintenance-free, pre-filled units.

The Predator 240 is large, thanks to a full-height double 120mm-fan radiator with a 6W Laing DDC pump and reservoir mounted on the end. The radiator section is nearly 300mm long and 68mm deep, so your case will need plenty of clearance around a double 120mm fan mount for installation.

The Predator 240 also features a small reservoir that enables you to drain and fill the loop yourself, and it uses standard tubing and G1/4in fittings. As such, you can easily replace the tubing if you want clear PVC or even hard acrylic, instead of using the black opaque tubing that EKWB supplies by default.

All the parts you need are included – there are two EKWB Varder 120mm fans in pull mode, some thermal paste and all the necessary mounting screws. The radiator section has a PCB that powers the fans and pump, with a detachable power cable that sports a SATA power connector on the other end to power the unit. There's also a 4-pin plug than taps into your motherboard's CPU PWM fan header, allowing the fans and the pump to run at slower speeds according to load – otherwise they run at 12V all the time.

/SPECIFICATIONS

Compatibility Intel: LGA2011, LGA2011-v3, LGA115x, LGA1366, LGA775

Radiator size with fans (mm) 133 x 68 x 295 (W x D x H)

Fans 2 x 120mm

Noise Not stated

Installation on an LGA2011 motherboard just requires the use of four thumbscrews, which are already attached to the Supremacy MX CPU waterblock.

They're dual-purpose, with thinner sections at the end for LGA115x sockets, but these tips pass through the thread holes on LGA2011 sockets, with the thicker threads below them securing the waterblock. LGA115x sockets also require you to remove the standard metal backplate, but this is a simple job and the right tool is included.

Performance

When running at 12V, the fans are pretty noisy, but using the 4-pin PWM header solves this problem at a stroke, making the Predator 240 quieter than any other all-in-one liquid cooler we've tested. Performance was mind-boggling too.

It was quieter and 9°C cooler than the Corsair H110i GT at its maximum fan speed in our LGA1150 system and 8°C cooler in our LGA2011 system. Using the motherboards' minimum fan profiles, the temperature rose by 2°C in the LGA1150 system, but limiting the fan speed to 12.5 per cent on our LGA2011 system resulted in a much bigger temperature increase of 22°C. Even so, this result still beat the likes of the Corsair H80i GT on its medium fan speed setting and, again, the Predator 240 was far quieter.

Conclusion

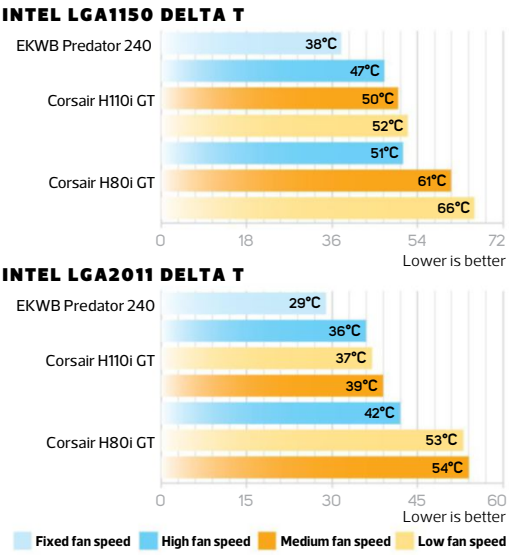
The EKWB Predator 240 is a stunning CPU cooler that's easy to install and provides a great starting point for an expandable water-cooling system. The only downsides are the price and the size of the radiator section – many cases'

ELITE
NEW ENTRY
P68

double 120mm fan mounts simply won't have enough room to accommodate it.

Price-wise, £170 is a lot just to cool your CPU, but the Predator isn't a run-of-the-mill all-in-one liquid cooler. It's a full-on custom kit that comes pre-assembled, and buying similar parts separately will cost significantly more money. You'll obviously miss out on the pleasure of building your own loop, but you'll benefit from the peace of mind of a leak-free installation and you'll be able to customise it further using standard parts too. If you're looking for the quietest and most powerful CPU cooler money can buy, without the hassle of creating a custom water-cooling loop, the Predator 240 is currently the best you can get.

ANTONY LEATHER



LGA115x

COOLING	DESIGN	VALUE	OVERALL SCORE
37/40	25/30	25/30	87%

LGA2011

COOLING	DESIGN	VALUE	OVERALL SCORE
36/40	25/30	24/30	85%

VERDICT

The Predator is the best all-in-one CPU cooler we've tested bar none, and it provides an excellent base from which to expand your water-cooling endeavours too.

HOW WE TEST PAGE 34

NAS BOX

Synology DS216play / £204 inc VAT

SUPPLIER www.ebuyer.com

Transcoding has been a spotlight feature on the last few Synology DiskStations, offering the ability to convert video to different resolutions and formats on the fly to ensure compatibility with various devices. However, the DS216play goes out guns blazing in the transcoding texts, with Synology claiming it can transcode 4K video on the fly – quite a feat when you consider that many NAS enclosures struggle to cope with 1080p.

This headline feature comes courtesy of a dedicated transcoding engine, although the circumstances in which it can tap into this engine's power are relatively limited. Not all third-party media servers support hardware-based transcoding – for example, Plex can't support it, and Plex is unlikely to be supported on the DS216play either, thanks to the use of an STiH412 Monaco Ultra ARM-based dual-core CPU.

It managed some of the quickest read speeds we've seen

The best option is Synology's own Video Station, which can dish out content to Android and iOS devices, and it includes Chromecast support. Not all 4K video formats are supported, though, and at the moment, only H.265/HEVC 3,840 x 2,160 video at 30fps, and H.264/AVC video at 24fps, can be transcoded on the fly. For a list of the specifics, it's worth taking a look at the DS216play's online product page.

Interestingly, the DS216play is also less well-equipped than its predecessor – the DS214play. It only has one USB 3 port instead of two, and there are no front panel ports, eSATA or USB copy buttons either. However, the claimed noise and power consumption are lower.

On the plus side, the current DSM5.2 software is a joy to use and loaded with useful features. Synology's Cloud server is second to none and was quick to set up for both local and remote access, as were its various media-related servers. Connecting to Chromecast via its Video Station app was generally smooth, although it did become laggy on occasions. Meanwhile, transcoding 4K video to watch on an iPhone 6 offered smooth playback, although the DiskStation's CPU usage peaked at over 80 per cent, with a fair amount of RAM being used too.

We then used Intel's NAS performance testing tool to gauge the DS216play's performance, where it managed some of the quickest read speeds we've seen, peaking at 101.5MB/sec in the quad-stream video playback test, and managing a healthy 99.8MB/sec in the file copy test. However, when writing, it returned average results in the same tests. The DS715, for example, was much quicker in the file copy write test, maxing out our Gigabit Ethernet connection at over 120MB/sec compared to 87.3MB/sec on the DS216play. Power consumption was low, though, with a peak draw of just 19.4W and, as usual for Synology, it was also one of the quietest NAS enclosures we've tested.

Conclusion

The DS216play is definitely capable of transcoding 4K video, but only in specific circumstances. Some formats and containers aren't supported and neither are many third-party media servers. Those services that do support the DS216play may not be able to use the hardware-based transcoding engine either. On the plus side, it's a fast NAS that's more than capable of dealing with 1080p transcoding in a variety of formats. There's clearly some serious power on offer here, but the lack of flexibility makes the DS216play's comparatively high price of £204 inc VAT hard to justify. If you don't need the very specific transcoding features, Synology's DS215J is still quick enough for most people's needs and significantly cheaper.

ANTONY LEATHER

SPEED	FEATURES	VALUE
31/35	29/35	22/30

OVERALL SCORE **82%**

VERDICT

On-the-fly 4K NAS transcoding is here, but it needs to be more flexible to justify the price.

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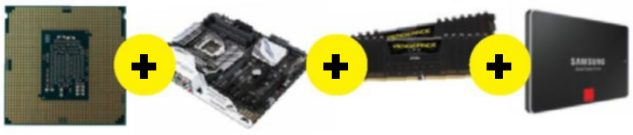
How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

PROCESSORS

We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1151



Intel LGA1151 CPU | Asus Z170 Deluxe | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 256GB Samsung 850 Pro

INTEL LGA2011-V3

Intel LGA2011-v3 CPU | Asus Rampage V Extreme | 16GB Corsair Vengeance LPX 2133MHz DDR4 | 512GB Crucial MX100

AMD FM2+

AMD FM2+ APU | MSI A88X-G45Gaming | 16GB Corsair Vengeance Pro 2133MHz DDR3 (GPU testing) | 8GB Corsair Vengeance Pro 1600MHz DDR3 (CPU testing) | 240GB Crucial M500

COMMON COMPONENTS

Nvidia GeForce GTX 780 3GB | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

*Please note: We test AMD FM2+ APUs using the on-board graphics, not the Nvidia GeForce GTX 780 3GB

GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.

4.2GHz Intel Core i5-3570K | 8GB Corsair Dominator 2400MHz DDR3 | Asus Maximus V Extreme | Windows 10 64-bit | The graphics card we're reviewing

CUSTOM PC REALBENCH 2015

INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB

AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1151

Intel Core i7-6700K | Motherboard on test | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100

AMD FM2+

AMD A10-7870K | Motherboard on test | 16GB Corsair Vengeance Pro 2133MHz DDR3

INTEL LGA2011-V3

Intel Core i7-5960X | Motherboard on test | Plextor M6 256GB | 32GB Crucial 2133MHz DDR4

COMMON COMPONENTS

AMD Radeon R9 390X* | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015 andTotal War: Attila, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum QPI, base clock or HTT as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

*Please note: We test AMD FM2+ motherboards using the on-board graphics, not the AMD Radeon R9 390X

TESTS: By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test GTA V, Shadow of Mordor, Crysis 3, Alien: Isolation and The Witcher III: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

The Awards

EXTREME ULTRA
Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.

PREMIUM GRADE
Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.

PROFESSIONAL
Products worthy of the Professional award make you and your business appear even more awesome.

APPROVED
Approved products are those that do a great job for the money; they're the canny purchase for a great PC.

CUSTOM KIT
For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

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Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

LIGHT BULBS

Sengled Pulse / £130 inc VAT

The best compliment we can give the Sengled Pulse (a set of two Bluetooth-equipped LED speaker bulbs) is that they give a sense of the future. Once installed in a room, a connected phone or tablet can control the room's lighting and audio – an idea that's really cool. Extra bulbs can be added and different zones of control created via the slick app.

However, the audio from the speakers is muddled, with little definition between different instruments, making music sound messy and flabby. The treble response is disappointing too, with high notes crackling if you push up the volume much past 50 per cent. Also, the size of the units means they won't be accommodated by every lampshade – two of the four lampshades we tried wouldn't fit with the Pulse speakers installed.

Even so, it's easy to see the potential of the technology and it's a great idea. The use of the light bulb form factor is also ingenious, as these powered sockets are already ubiquitous and usually fitted in the centre of a room. With a bit of work on what's already a good idea, the next revision of the Sengled Pulse could be pretty special, but the quality of the speakers means we can't recommend it in its present form.

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SUPPLIER www.amazon.co.uk

LAPTOP BAG

Booq Cobra Brief / £220 inc VAT

We've previously praised Booq's blend of premium materials and idiosyncratic design, but only the former is present with the Cobra Brief – visually, it's as plain as a concrete wall. That doesn't prevent it from being spacious, of course – a laptop (up to 15.6in), tablet, book, smartphone and all the associated cabling can all be slotted easily into its padded interior, which is sensibly laid out and easily accessible thanks to its large, three-side opening. It's comfortable to wear and the built-in Terralinq lost-luggage retrieval system is as useful as ever. However, with a price of £220, we expect some design thrills too.

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SUPPLIER www.amazon.co.uk

ACTIVITY MONITOR

Jawbone UP3 / £130 inc VAT

Despite weighing just 29g, the Jawbone UP3 claims to be able to track your daily activity, sleep patterns and heart rate. When it works, the data is fascinating. It's great seeing your heart rate plotted throughout the day, with the peaks (taking the stairs, rather than the lift) and troughs (that two-hour meeting) clearly visible.

Consistency was an issue though. It wasn't great at noticing when we we'd started exercising and it seemed too eager to interpret sitting on the sofa as being asleep. The band needs to be fitted tightly to get a good heart rate reading too. On the plus side, the Jawbone activity tracking app is one of the best we've seen. Data is clear, and the Smart Coach (which gives advice based on your data) is genuinely useful.

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SUPPLIER www.jawbone.com

TOY GUN

NERF Modulus ECS-10 Blaster / £49 inc VAT

NERF Modulus ECS-10 Upgrade kits / £18 (each) inc VAT

As anyone who is unlucky enough to have been in our office over the last few weeks will confirm, the NERF Modulus has seen a lot of 'testing' in the time we've had it. Designed to be highly customisable, the system is based around a semi-automatic blaster that fires darts using a battery-powered flywheel. This system is great, as there's no need to cock the blaster between shots. The system is powerful too – flinging the darts a good 15m, although they did tend to arc randomly during flight. The flywheel is noisy too, so sneak attacks are nearly impossible.

There are also 14 accessories that enable you mod the blaster, the first five of which are included in the starter pack 1. The other nine are available as one of four upgrade kits. Of these kits, the Flip Clip kit 3 is handy due to the included 24 darts – the blaster only comes with a miserly ten shells, which it spits out in mere seconds. The Strike and Defend Kit 5 is also fun thanks to the Blaster Stock that doubles as a sneaky, last-resort single-shot pistol.

The remaining kits have less tangible benefit – the Stealth kit 2 doesn't make the blaster any quieter (although the red dot sight is cool), and the Long Range kit 4 doesn't increase its range. Playing with the blaster is great fun, though, at least until you're out of ammo and need to pick up all the darts.

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SUPPLIER www.toysrus.co.uk

BLUETOOTH SPEAKER

Divoom AuraBox / £50 inc VAT

At first glance, the AuraBox looks like a dinky Bluetooth version of those awful light boxes used by cheesy wedding DJs. In one regard, that's not far off the mark – most of the display settings just flash the colourful 10 x 10 display inanely along to whatever music is being pumped out of the competent, rather than spectacular, rear-facing speaker. The one highlight is the clock mode; when combined with the alarm settings in the free companion app, this turns the speaker into a stylish alarm clock. The app also allows you to program the display yourself, which sounds like fun right up until you realise that drawing any design with such a limited resolution and colour gamut is next to impossible.

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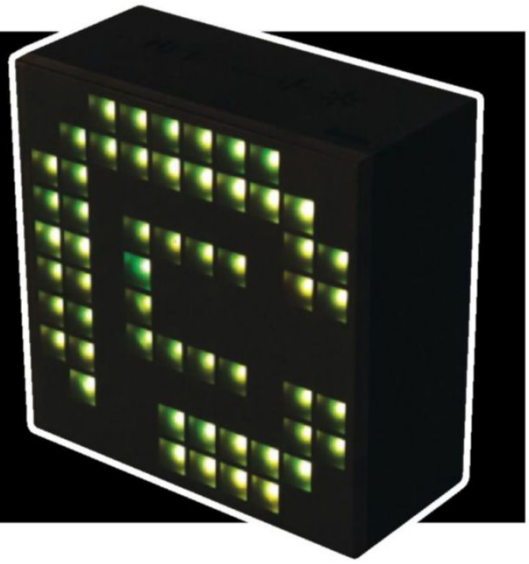
SUPPLIER www.amazon.co.uk



Seen something worthy of appearing in Custom Kit? Send your suggestions to paul_goodhead@dennis.co.uk

LABS TEST

Graphics galore

We test 12 GPUs in five games across three resolutions, from 1080p to 4K, to find the best bang for your buck

The graphics card is the epicentre of performance in a gaming PC, much more so than the CPU or memory. Get the right graphics card for your needs, and you'll be able to play all of the latest games at the resolution of your choice. In the eight months since we last conducted a Labs test, AMD has replaced its Radeon 200-series with the 300-series, and introduced its Fury cards with high bandwidth memory (HBM). Meanwhile, Nvidia has filled out its Maxwell range at both the top and bottom of the pack, releasing both the GeForce GTX 950 and the GTX 980 Ti.

The result is a complete reshuffling of the whole GPU pack, with new technology sitting among rebranded older technology. Both Nvidia and AMD have had to cope without a shrink from the current 28nm manufacturing process, but AMD has still shaken up the industry with the introduction of HBM on its Fury and Nano cards, offering an incredible 4,096-bit memory interface. On the other hand, though, the rest of AMD's GPU range is made up of older GPUs that have been tweaked and rebadged.

Either way, the recent crash in the price of 2,560 x 1,440 and 4K monitors means many PC gamers are now demanding more GPU gaming power than beforehand, with 1080p considered just the bare minimum.

If you're thinking of making the push to one of these higher resolutions, or if you just want to play the latest games at 1080p, this Labs test will tell you exactly what you need, advising you on the best graphics card in several price brackets.

MATTHEW LAMBERT AND ORESTIS BASTOUNIS

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AMD Radeon R7 370 2GB / p42
Nvidia GeForce GTX 950 2GB / p42
Nvidia GeForce GTX 960 2GB / p43
AMD Radeon R9 380 2GB / p44
AMD Radeon R9 390 8GB / p46
Nvidia GeForce GTX 970 4GB / p47
AMD Radeon R9 390X 8GB / p48
Nvidia GeForce GTX 980 4GB / p50
AMD Radeon R9 Fury 4GB / p50
Nvidia GeForce GTX 980 Ti 6GB / p51
AMD Radeon R9 Fury X 4GB / p52
Nvidia Titan X 12GB / p54

How we test

All our graphics tests are performed on a high-end Ivy Bridge system, which features an Asus Maximus V Extreme LGA1155 motherboard and an Intel Core i5-3570K running at 4.2GHz. Alongside these components is 8GB (2 x 4GB) of Corsair Dominator 2400MHz DDR3 RAM and a 480GB SanDisk Extreme Pro SSD. Meanwhile, power comes from a LEPA G1600 1,600W PSU.

We've tested each card in five separate games. We record the most demanding parts of the built-in benchmarks for three games: Alien: Isolation, GTA V and Middle Earth: Shadow of Mordor. Crysis 3 is tested using a custom, 60-second macro-recorded play-through from the single-player mission Red Star Rising and, finally, for The Witcher III: Wild Hunt, we record a 45-second manual play-through of Geralt entering and passing through a village on horseback. We record every test using the freely available FRAPS tool to ensure accuracy, and each test is performed three times for consistency.

All cards are tested at reference frequencies and at 1,920 x 1,080 (1080p), 2,560 x 1,440 and 3,840 x 2,160 (4K) with v-sync disabled. Alien: Isolation is tested at maximum settings, as is Crysis 3, although anti-aliasing is left off in the latter. Shadow of Mordor is tested at Ultra, except at 4K where we drop to Very High. For GTA V, we test using the Very High presets and in The Witcher 3, we use the High presets with Nvidia HairWorks disabled.

Scoring standards

We've adopted a weighted scoring system for GPU group tests that's designed to highlight meaningful and real-world performance differences. The Performance component of the final scores is calculated through a point-based system, with points allocated based on the minimum frame rate achieved in each test. We focus on minimum frame rates, as it's these that you'll really notice when your games slow down.

Crysis 3 is tested using a custom, 60-second macro-recorded play-through from the single-player mission Red Star Rising

For The Witcher III: Wild Hunt, we record a 45-second manual play-through of Geralt passing through a village on horseback

A result of between 25fps and 29fps, which we've consistently considered to be borderline playable, receives just one point. We consider 30fps to be the true minimum target for games to remain smooth and playable. As such, a minimum of 30fps or more is worth three points. If a minimum result exceeds 45fps, we award an extra half point as the game will feel a little smoother than at 30fps. It also means a card has more headroom for future titles and will be capable of hitting 60fps with fewer sacrifices to details.

Lastly, any card whose minimum is above 60fps is awarded the full four points for that test. With the raw scores tallied up, we weigh the cards against each other to calculate a Performance percentage for each resolution. The 1080p tests carry the heaviest weighting of the final score (25 per cent), followed by 2,560 x 1,440 (15 per cent) and 4K (10 per cent).

The Value score (40 per cent) is then calculated by dividing the total performance points by the cheapest available model of a given card at the time of writing. The final 10 per cent comes from the Efficiency score, which is based on how well the card performs across the tests compared with its power consumption under load (measured using Unigine Valley).

This complex scoring method is designed to put the onus on real, useful performance in the current generation of games. As a result, less expensive cards may have relatively low final scores due to their inability to perform at high resolutions, but that's no concern if you're on a budget and playing at 1080p. As such, the final scores aren't the only elements that count towards awards – we're looking for the best cards within certain price brackets and show what you'll need to play games smoothly at your monitor's native resolution.

We've also included results for Unigine's free Valley benchmark, a demanding DirectX 11 test. It's run at 1,920 x 1,080 with Ultra detail and anti-aliasing disabled. This test doesn't count towards the final score but can be used as a way to compare your current setup to the cards tested here.

We record the most demanding parts of the built-in benchmarks for three games: Alien: Isolation, GTA V and Middle Earth: Shadow of Mordor

AMD R7 370 2GB / £110 inc VAT

SUPPLIER www.novatech.co.uk

The AMD R7 370 has the honour of being the most affordable card on test, saving you £10 over its close rival, Nvidia's GTX 950. As with a few of AMD's GPUs from its current generation, it's a refresh and rebrand of a previous model, the R7 270, a card that borrowed the same GPU from the HD 7850 before it.

As such, the R7 370 is based on the aging Graphics Core Next 1.0 core, unlike AMD's more powerful GPUs, which go up to Graphics Core Next version 1.2.

As you'd expect at this relatively low price, the R7 370 offers a modest hardware specification, with 2GB of GDDR5 memory, just 1,024 stream processors, 64 texture mapping units (TMUs) and 32 ROPs, a configuration that's dwarfed by the larger, more expensive AMD GPUs.

To alleviate this deficiency, the exact clock speeds aren't much slower than those of even the top-end cards, with the core running at 975MHz and the memory running at 1.4GHz (5.6GHz effective), giving a total memory bandwidth of 179.2 GB/sec with the 256-bit memory interface.

However, the low stream processor count limits the R7 370 to 1080p gaming. Of course, you can't expect a £110 card to play games at 4K, but it only stayed above 30fps in one 2,560 x 1,440 test, Alien: Isolation, and it was only able to offer borderline playable frame rates in The Witcher III, and Crysis 3 at 1080p. Of course, Nvidia's GTX 950 similarly struggles at the higher resolutions, but overall that card can play all our test games, bar one, at 1080p, making it a slightly faster card. The bigger problem for the R7 370, though, is that you can get a card based on AMD's own R9 380 for just £148 inc VAT, which plays all our test games at 2,560 x 1,440 and offers much better value for money.

The GTX 950 is also a little more power-efficient than the R7 370, with our test system

Nvidia GeForce GTX 950 2GB / £120 inc VAT

SUPPLIER www.scan.co.uk

The GeForce GTX 950 bridges the gap between the GTX 750 Ti and the slightly more expensive GTX 960. The GTX 950 uses the same second-generation Maxwell design, codenamed GM206, which first appeared in the GTX 960. It fully supports DirectX 12.1, along with H.265 encoding via Nvidia's upgraded video engine, plus HDMI 2 and G-Sync.

The physical die area measures just 227mm^2 and it's backed up by 2GB of GDDR5 memory. As with the GTX 960, this memory is addressed via a comparatively narrow 128-bit memory interface, and there are only two graphics processing clusters (GPCs), as opposed to the four found in the GTX 970. With the GTX 950, Nvidia has gone further in its drive for austerity, though, disabling two of the GTX 960s streaming multiprocessors (SMs), so there are now 48 texture units rather than the GTX 960's 64, six tessellation units rather than the eight in the GTX 960, and 768 stream processors instead of 1,024.

Clock speeds are slightly lower as well, with a base clock of 1024MHz (1188MHz boost) and a memory clock of 1.65GHz (6.6GHz effective). However, the base clock has only been reduced by around 10 per cent compared with the GTX 960, and the card still offers 105.6GB/sec memory bandwidth, which is only a small drop from the 112GB/sec of the GTX 960.

On the plus side, the GeForce GTX 950 is quicker in most of our 1080p tests than AMD's similarly low-cost Radeon R7 370, and if you don't plan to play games at settings higher than this resolution, the GTX 950 will do the job fine.

However, spending just an extra £28 on the Radeon R9 380 will open up 2,560 x 1,440 gaming, and that's the GTX 950's main problem. Where the GeForce GTX 950 really excels, though, is power consumption, with our system drawing just 212W from the mains at full load.

consuming 212W at load with the GTX 950 installed, compared to 234W with the R7 370 fitted. The difference is only slight here, though, unlike the difference in power consumption between Nvidia and AMD's top-end GPUs.

Conclusion

The Radeon R7 370 looks like great value for money at first, but every other card on test generally outperforms it, and none of them costs much more money. An extra £10 gets you superior 1080p performance from the GeForce GTX 950, while the R9 380 costs £38 more and makes gaming at 2,560 x 1,440 a real possibility.

1920 SPEED	2560 SPEED	3840 SPEED
14/25	3/15	0/10

VALUE	EFFICIENCY
28/40	6/10

VERDICT

A tempting price, but £38 extra will get you much more bang for your buck from the Radeon R9 380.

OVERALL SCORE **51%**

Conclusion

The GTX 950 isn't bad for the money, offering slightly better 1080p performance than AMD's R7 370, although both cards are overshadowed by the GTX 960 and R9 380, which only cost a small amount extra and are significantly more powerful. Don't worry if you've bought one on our recommendation after last month's review – the GTX 950 remains a solid 1080p card.

If you're never going to play games beyond 1080p, and power efficiency is a top priority, the GTX 950 will do the job fine, but you'll get much more bang for your buck by spending a little more money on the Radeon R9 380.

1920 SPEED	2560 SPEED	3840 SPEED
17/25	4/15	0/10

VALUE	EFFICIENCY
33/40	9/10

VERDICT

Fine for 1080p, and very power-efficient, but a little more cash buys much more power.

OVERALL SCORE **63%**

Nvidia GeForce GTX 960 2GB / £130 inc VAT

SUPPLIER www.overclockers.co.uk

The GeForce GTX 960 has the best specification that Nvidia offers for under £150 – the next step up is a steep jump to the £240 GTX 970. The GTX 960 is based on the GM206 second-generation Maxwell core, as used in the GTX 950. In order to bring down the price, this 227mm² chi offers considerably less rendering hardware than the 398mm² GPU in the GM204 Maxwell core in the GTX 970 and 980, but unlike the GTX 950, though, none of the GTX 960 GPU parts has been disabled.

You get two graphics processing clusters (GPCs) divided into eight streaming multiprocessors (SMMs), eight tessellation units (TUs), 64 texture mapping units (TMUs), 32 ROPs and 1,024 stream processors. It's exactly half the amount of hardware offered by the GTX 980. The card also includes 2GB of GDDR5 video memory, and a surprisingly narrow 128-bit-wide memory interface, which could hamper higher-resolution performance.

Interestingly, clock speeds are almost identical to the GTX 980, with a 1127MHz base clock (1178MHz boost) and a 1175MHz (7GHz effective) memory clock. Only the boost clock has been reduced slightly. It's not a bad offering, considering current pricing. Although the launch price of the GTX 960 was £160, it's now being sold for considerably less money, costing only £10 more than the GTX 950, which makes a significant difference to its value relative to other mid-range cards.

Both the GeForce GTX 950 and AMD's Radeon R7 370 can manage playable frame rates in games at 1080p, but struggle at 2,560 x 1,440 and above.

In AMD's case, the next best GPU, the R9 380, opens up 2,560 x 1,440 gaming, with minimum frame rates of at least 25fps in every game test.

That's a problem for the GTX 960, which dropped to 23fps in Crysis 3 and 24fps in Shadow of Mordor at 24fps. As expected, neither card is much cop at 4K either, but both sail past 30fps at 1080p.

Where the GTX 960 has the upper hand over the R9 380 is power efficiency, with our system only drawing 231W from the mains at full load with the GTX 960 installed, compared to 295W with the R9 380 in place.

Conclusion

If you want a mainstream Nvidia card, the close pricing between them makes the GeForce GTX 960 a much better proposition than the GTX 950, and its power efficiency is excellent too. It's a close call between the GTX 960 and the R9 380, which both have pros and cons, but the R9 380's ability to play games at 2,560 x 1,440 for under £150 makes it our GPU of choice in this price league.

1920 SPEED	2560 SPEED	3840 SPEED
20/25	5/15	0/10

VALUE	EFFICIENCY
36/40	9/10

VERDICT

A good price and great power efficiency, but the R9 380 is faster at high resolutions.

OVERALL SCORE **70%**

ELITE NEW ENTRY P68

AMD Radeon R9 380 2GB / £148 inc VAT

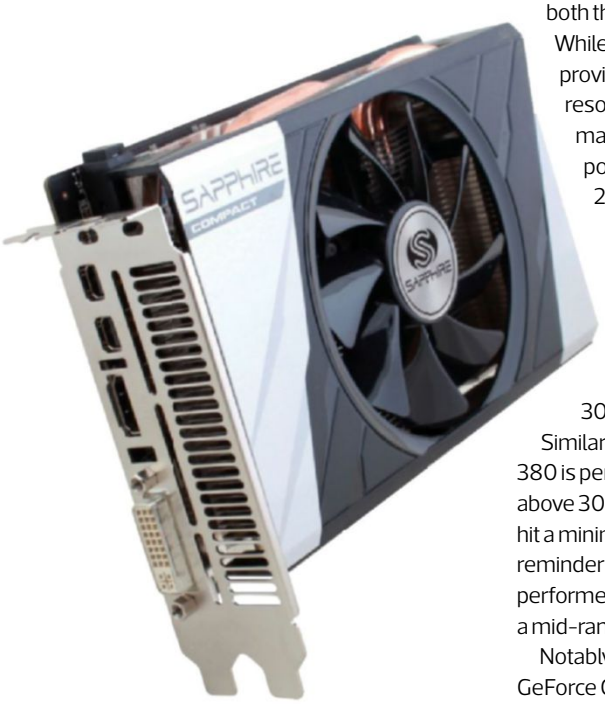
CUSTOM PC APPROVED

SUPPLIER www.ebuyer.com

Despite only costing £38 more than AMD's Radeon R7 370, the Radeon R9 380 has a considerably more powerful specification. It's based on the GCN 1.2 Antigua Pro core (a new name for AMD's Tonga design), with 5 billion transistors, a sharp increase over the R7 370's 2.8 billion, and it has a larger 359mm² die as well. Similarly, its stream processor count of 1,792 with 112 TMUs is a big increase over the specs of the R7 370, although some aspects remain – it still has a 256-bit wide memory interface, and there's only 2GB of GDDR5 memory, although that's still enough for the resolutions and settings that most gamers use.

The specs might sound familiar too because, like many current AMD GPUs, the R9 380 is another rebrand, this time of the Radeon R9 285, but with slightly higher clock speeds. The core clock is now 970MHz, with a 1.4GHz memory clock (5.6GHz effective), giving you a total memory bandwidth of 182.4GB/sec.

What's more, for anyone with a mini-ITX case, Sapphire's R9 380 Compact Edition (pictured) is the best-performing AMD graphics card you can buy in a small form factor (the PCB measures just 170mm long) before you get to the much pricier Nano cards. Although most mini-ITX cases can accommodate larger cards, it's handy to use a smaller one if possible to give yourself more room for airflow and cable routing.



The R9 380 makes 2,560 x 1,440 gaming a real possibility, never dropping below 25fps

When it comes to gaming performance, it isn't hard to see the effect of all this extra hardware. Of course, gaming at 4K isn't really possible with any of the mid-range cards on test, but the R9 380 is a clear step up from both the R7 370 and Nvidia's GTX 950. While the R7 370 was incapable of providing consistently smooth gaming at resolutions above 1080p, the R9 380 makes 2,560 x 1,440 gaming a real possibility, never dropping below 25fps in any of our tests.

There's a caveat, though, since it still didn't quite hit a minimum frame rate of 30fps in three out of our five games at 2,560 x 1,440 – Crysis 3, Shadow of Mordor and The Witcher III – and we consider 30fps to be the ideal minimum.

Similarly, while 1080p gaming on the R9 380 is perfectly adequate, with every result above 30fps, only one out of the five games hit a minimum frame rate above 60fps, a reminder that despite being a strong performer in its category, the R9 380 is still a mid-range card.

Notably, however, the R9 380 beats the GeForce GTX 960 in almost every test at 2,560 x 1,440, with consistently better frame rates, although the two cards exchange blows in the 1080p tests. Either way, with the ability to play all our test games at 2,560 x 1,440, and stay above 30fps at 1080p, the R9 380 is clearly the king of mid-range performance. The only downer, as with all of AMD's current GPUs, is power consumption. At full load, our system consumed over 60W more with the R9 380 installed than with the GTX 960 fitted, showing that AMD has some work to do when it comes to power efficiency.

Conclusion

If you have a limited budget to spend on a graphics card, the R9 380 will do you proud. For the extra £38 it costs over the R7 370, you get a card that's capable of both 1080p and 2,560 x 1,440 gaming. Pricier cards offer even better value in terms of bang per buck, of course, but that's irrelevant if you have a limited budget, and in the sub-£150 league the R9 380 is the best GPU on test.

1920 SPEED	2560 SPEED	3840 SPEED
20/25	7/15	1/10

VALUE	EFFICIENCY
36/40	7/10

VERDICT

The best sub-£150 GPU on test, managing playable frame rates at 2,560 x 1,440.

OVERALL SCORE **71%**

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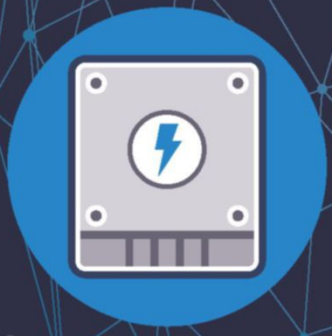

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AMD Radeon R9 390 8GB / £230 inc VAT

SUPPLIER www.overclockers.co.uk

The AMD Radeon R9 390 is a cheaper and slightly less powerful version of the R9 390X in the same way that the GeForce GTX 970 is related to the GTX 980. As such, it sits at the same important price point, below £300 but well above the £150 of the mainstream GPUs below it, offering great frame rates, but without the significant premium attached to premium beasts such as the Fury X.

Both the R9 390 and 390X use the same Hawaii GPU core, which is a 6.2 billion-transistor chip with a 438mm^2 die. In the case of the R9 390, it's a Hawaii Pro, which is the same core found in the Radeon R9 290. It has 2,560 stream processors, 160 TMUs and 64 ROPs. The main difference is the clock speed, with the R9 390 running at 1GHz, rather than the maximum 947MHz of the R9 290.

The R9 390 also notably lacks the new HBM technology of the Fury and Fury X, and the 4,096-bit memory interface that comes with it. Instead it has 8GB of traditional GDDR5 memory, addressed over a 512-bit interface, running at an effective speed of 6GHz for 276GB/sec of memory bandwidth. In contrast, the pricier R9 390X with its Hawaii XT core offers 16 more TMUs, and a stream processor count of 2,816, for added performance.

Since the R9 390 aims to hit the sweet spot between value and performance, we were particularly interested in how its performance compared with both the R9 390X and the 390's main competitor, Nvidia's GeForce GTX 970. In this tier of graphics cards, 4K gaming becomes a possibility, with the R9 390 achieving minimum frame rates above 30fps in three of our tests – only The Witcher III and Crysis 3 slipped below the playability threshold at this resolution. Likewise at 1080p, those same two demanding titles were the only tests that couldn't hit 60fps, although the rest sailed past this frame rate. All the games presented playable frame rates above 30fps at 2,560 x 1,440 as well, showing a solid benefit over the cheaper R9 380.

Meanwhile, the more powerful R9 390X costs an extra £70, but only offers slightly better frame rates across the board – in some cases, a difference of just 1fps. With the notable exception of The Witcher III at 4K, which just hits 25fps, the 390X doesn't magically open up other games to higher resolutions that can't be run on R9 390, so the R9 390 offers the better bang per buck when it comes to performance.

The R9 390 also performs similarly to the GTX 970, which costs just £10 more. The GTX 970 equally manages playable frame rates in the same games at 1080p and 2,560 x,1,440, while the R9 390 gets one extra point for never dropping below 30fps in Shadow of Mordor at 4K.

Unfortunately, though, the R9 390 loses out in a big way in terms of power efficiency. A high TDP is the Achilles heel of the Hawaii GPU when it runs at a high clock speed. Under load, our system consumed 437W with the R9 390 installed, more than any other graphics card on test, while it only drew 266W from the mains with the GTX 970 fitted. That's a massive difference of 171W that will have a real impact on your electricity bill over time, and the R9 390 gets hot too.

Conclusion

The R9 390 offers a great balance of performance and value for money. It provides smooth gameplay at 2,560 x 1,440 without dropping below 30fps, and it can even play some games at 4K. However, while the slightly more expensive GTX 970 offers the same performance levels, it does so in a much more power-efficient way, making the GTX 970 our card of choice in this segment.

1920 SPEED	2560 SPEED	3840 SPEED
23/25	12/15	5/10

VALUE	EFFICIENCY
37/40	6/10

VERDICT

Decent performance, but its power consumption is ridiculous next to the GeForce GTX 970.

OVERALL SCORE **83%**

Nvidia GeForce GTX 970 / £240 inc VAT

SUPPLIER www.awd-it.co.uk

Nvidia's GeForce GTX 970 uses the same GM204 core as its bigger sibling, the GTX 980. It's a powerful 5.2 billion-transistor chip with four graphics processing clusters (GPCs), each of which is split into 16 streaming multiprocessors (SMs) giving you a total of 2,048 stream processors. However, in the case of the GTX 970, three of those SMs have been disabled. As a result, its tally of stream processors drops to 1,664, while it has 13 tessellation units rather than the GTX 980's 16, and 104 texture units rather than the GTX 980's 128. The base clock has been lowered very slightly as well, from 1126MHz (1216MHz boost) on the GTX 980 to 1050MHz (1178MHz boost) on the GTX 970.

However, it's the similarities that matter more in this case. The GTX 970 still has 4GB of GDDR5 memory running at 1.75GHz (7GHz effective) over a 256-bit memory interface, resulting in the same 224GB/sec of memory bandwidth of the GTX 980. It also still has 64 ROPs – one of the most important aspects of the rendering pipeline.

Perhaps more importantly, the GTX 970's price is around a third lower than that of the GTX 980, costing just £240 inc VAT and aiming to hit the sweet spot between value and performance.

It's certainly a big upgrade over the GTX 960 in terms of performance. No game we tested offered playable minimum frame rates over 25ps with that card at 4K, but the GTX 970 managed this achievement in three out of our five test games. The GTX 970 also never dropped below 60fps in three of our 1080p tests. Crucially, the GTX 970 also stayed above 30fps in all our tests at 2,560 x 1,440, while the GTX 960's minimum couldn't hit 25fps in two of our games at this resolution.

> Our test rig consumed just 266W at load with the GTX 970 installed

At the other end of the scale, the £130 premium attached to the GTX 980 isn't easily justified in our tests. Of course, the GTX 980 offers generally better frame rates, but there's only a small difference in terms of the level of playable performance between the two GM204 cards. At 4K resolution, The Witcher III reaches a playable 25fps on the GTX 980, while the Shadow of Mordor minimum goes above 30fps, but that's pretty much it. In every other test, the GTX 970 is nearly as good in terms of real world gains – if you want to play all games at 4K, you need to take another step up again.

Competition is very tight with AMD's R9 390 though. This chip generally equals the GTX 970 in terms of playable frame rates at each resolution, and slightly beats it in terms of actual frame rates, and it costs £10 less too. However, the GTX 970 has the amazing power efficiency of Nvidia's Maxwell architecture under its belt, with our test rig consuming just 266W at load with the GTX 970 installed. Comparatively, our system drew 437W from the mains with the R9 390 installed. With such a low TDP, it's also possible to make small GTX 970 cards, such as the Asus DirectCU Mini pictured, which are ideal for tidy mini-ITX builds.

Conclusion

Although everyone's budget is different, the GTX 970 offers the best balance between price and performance of any graphics card on the market, and it does so without the ridiculous power consumption of AMD's Radeon R9 390. In terms of raw performance, that card has the very slight upper hand, but in terms of playable frame rates, the GTX 970 is just as good. By striking the performance and value sweet spot on target, and offering amazing power efficiency, the GTX 970 is currently the best GPU you can buy in terms of bang per buck.

1920 SPEED	2560 SPEED	3840 SPEED
23/25	12/15	4/10

VALUE	EFFICIENCY
35/40	10/10

VERDICT

Strikes the ideal balance between performance and value, without sky-high power consumption.

OVERALL SCORE 84%

AMD Radeon R9 390X 8GB / £300 inc VAT

SUPPLIER www.overclockers.co.uk

Although AMD has squeezed three GPU generations out of its Graphics Core Next architecture, it isn't strictly accurate to say the cards are simply rebadges. Despite the basic technology being the same as the R9 290X before it, thanks to a few tricks and tweaks from AMD, the Grenada XT core (the new name for Hawaii XT) in the Radeon R9 390X can be clocked at higher frequencies than its predecessor, and it's capable of churning out great frame rates.

The core specifications are indeed unchanged from the 290X, though, with 2,816 stream processors, 176 TMUs and 64 ROPs making up the same rendering engine. However, AMD has made a small change to the core clock speed, which has increased by 50MHz to 1050MHz.

It's the memory that's seen a greater improvement though. Although there's no HBM, as that's only found in the Fuji-based Fury cards, the R9 390X now has 8GB of GDDR5 video memory as standard, double the amount on a standard 290X card. It runs considerably faster too with a 1500MHz (6GHz effective) memory clock speed, quite a boost from 1250MHz (5GHz effective). As it's addressed across a 512-bit bus, the overall memory bandwidth has increased by 20 per cent, from 320GB/sec to 364GB/sec.

At £300, the R9 390X also fits into a price bracket that doesn't really have any competition from Nvidia. The GTX 970 (and R9 390) cost under £250, while the GTX 980 and Fury cards are much more expensive, costing closer to £400. As such, the R9 390X might look appealing if you want more power than an R9 390, but your budget can't quite stretch to the Fury cards.

However, the R9 390X struggled to justify its premium in our performance tests, with its frame rates being only slightly quicker than those of the much cheaper R9 390. On the plus side, the 390X hit a borderline playable minimum of 25fps in The Witcher III at 4K, compared to 21fps on the 390, but the difference was otherwise very slight.

A part of the 390X's problem is certainly that the R9 390 is already a great card. It has slightly fewer stream processors and TMUs, but it also has 8GB of GDDR5 memory running at the same clock speed as the R9 390X, and therefore has the same 364GB/sec memory bandwidth. Perhaps more importantly, though, the other main similarity between the R9 390 and 390X is monstrous power consumption. Our test system drew 436W from the mains at load with the 390X installed – 137W more than a GTX 980 – and it gets hot.

Conclusion

The AMD Radeon R9 390X offers very good overall performance, but the difference between the 390X and the much cheaper 390 is so slim that you may as well save yourself some cash and buy a cheaper GeForce GTX 970 or vanilla R9 390 instead, with the former offering the better balance of performance and efficiency.

If you want significantly better performance than either of these two cards, you'll need to dig deeper into your wallet and move up to the GTX 980 or R9 Fury.

1920 SPEED	2560 SPEED	3840 SPEED
23/25	12/15	5/10

VALUE	EFFICIENCY
30/40	6/10

VERDICT

Solid performance, but power consumption is sky high, and you can get better value elsewhere.

OVERALL SCORE 76%

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AMD Radeon R9 Fury 4GB / £400 inc VAT

SUPPLIER www.novatech.co.uk

The Radeon R9 Fury X, based on AMD's Fiji core, is currently the firm's most powerful GPU on the market, with liquid cooling as standard and high-bandwidth memory (HBM) attached to a super-wide 4,096-bit memory interface. So how much of this interesting technology remains in the slimmed-down, non-X variant. What stays, what gets cut and how much difference does it make?

The liquid cooling has gone in the vanilla Fury, coming with a traditional air cooler as standard, as with the Sapphire card we've reviewed. HBM is here to stay, though, and the Fury still has 4GB of it running at 500MHz (1GHz) effective like the Fury X. Don't be fooled by those low numbers, though, as the wide memory interface negates the need for high clock speeds, and both Fury cards offer 512GB/sec memory bandwidth – more than any other GPU.

The relationship between the Fury and Fury X mirrors that of the R9 390 and R9 390X. The Fury has a base clock that's 50MHz slower, at 1GHz, and it has 3,584 stream processors – 512 fewer than the 4,096 on the Fury X. There are also 32 fewer TMUs, with 224 rather than the 256. The Fury is priced £100 less than the Fury X, though, marking it as a potential alternative to Nvidia's GTX 980.

In our tests, the Fury achieves better 4K results than the GTX 980, managing playable frame rates in Crysis 3, which was too much for the GTX 980. However, the GTX 980 hits the magic 60fps goal in GTA V at 2,560 x 1,440. It's a close call between the two cards in terms of performance, though, and the Fury is generally very competitive against GTX 980, often outperforming it.

As with many of AMD's current GPUs, though, the main fly in the ointment is power

Nvidia GeForce GTX 980 4GB / £370 inc VAT

SUPPLIER www.ebuyer.com

Last year, the GeForce GTX 980 was the most powerful Maxwell card in Nvidia's arsenal, well deserving of the Extreme Ultra award it received in the last Labs test. Fast forward to late 2015 and there are now several cards sitting above it.

While it's no longer Nvidia's flagship card, though, the GTX 980 is still equipped with plenty of grunt to cope with high-resolution gaming. It uses the full-fat 398mm^2 GM204 core, and unlike the GTX 970, none of its parts is disabled. As such, you get eight GPCs, 16 SMs and a total of 2,048 stream processors, along with 64 ROPs, 128 TMUs and 16 tessellation units. It's a beefy hardware specification, and one that ensures the GTX 980 remains a top performer.

There's 4GB of GDDR5 video memory, running at 1.75GHz (7GHz effective) across a 256-bit memory interface, which delivers 224GB/sec of memory bandwidth. Meanwhile, the GPU has a core clock speed of 1126MHz (1216MHz boost). Given that the GTX 980 has been on sale for a while now, and is no longer the fastest single-GPU card around, its price has come down a little since the last Labs test, so it now fits between its two closest competitors from AMD: the £300 Radeon R9 390X and the £400 R9 Fury.

As expected, its performance fits between the two AMD cards as well. As you'd hope for a £370 video card, it copes perfectly well with gaming at 1080p, remaining above 60fps at all times. It doesn't drop below 60fps in two of the 2,560 x 1,440 tests as well, while even the Fury only manages a 60fps minimum in one game at this resolution. The Fury has the slight advantage at 4K, though, managing playable (25fps) frame rates in every game, while the 980 can't quite hit this point in our most demanding test game, Crysis 3.

It's a close call, but Nvidia gets a few extra points for the better efficiency of the Maxwell architecture. Our test system drew just 300W from the mains at load with the GTX

consumption. While we're pleased to see the Fiji cards drawing less power than their Hawaii counterparts, our test system still drew 422W under load with the Fury installed, compared to just 300W from the GTX 980, which also has a slightly cheaper price.

Conclusion

The Radeon R9 Fury offers formidable performance and better value for money than the Radeon R9 Fury X, and it's also the cheapest card on test to offer playable frame rates in all our games at 4K.

However, the cheaper GTX 980 gives it a serious run for its money, especially when it comes to power consumption.

1920 SPEED	2560 SPEED	3840 SPEED
24/25	13/15	6/10

VALUE	EFFICIENCY
25/40	7/10

VERDICT

Plays every game at 4K, but the GTX 980 is cheaper and much more power-efficient.

OVERALL SCORE **75%**

980 installed, which is remarkable efficiency for such a powerful GPU – even the Fury with its HBM tech pushed up our system's power consumption to 422W, which is significantly higher.

Conclusion

The GTX 980 can still rock some very impressive gaming performance. AMD provides some really tough competition from the Radeon R9 Fury, but the GTX 980's amazing efficiency and slightly lower price propels it into the lead in this league. The only disappointment is that it can't quite play every game at 4K.

1920 SPEED	2560 SPEED	3840 SPEED
25/25	13/15	5/10

VALUE	EFFICIENCY
26/40	10/10

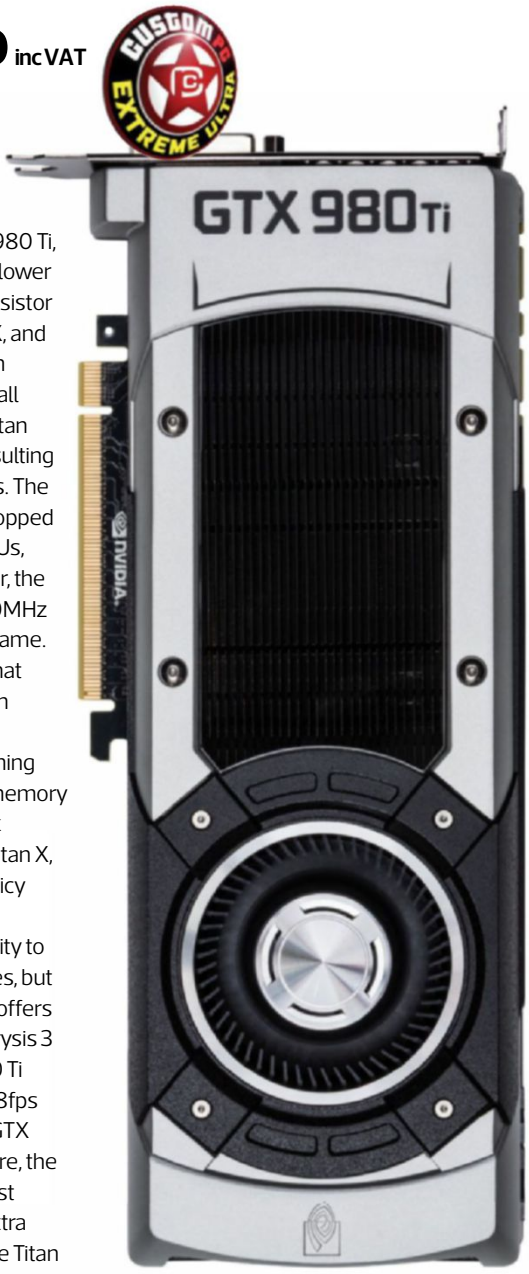
VERDICT

Great performance and power efficiency, although it can't play every game at 4K.

OVERALL SCORE **79%**

Nvidia GeForce GTX 980 Ti 6GB / £530 inc VAT

SUPPLIER www.overclockers.co.uk



Early Titan X adopters may have been miffed by the launch of the GTX 980 Ti, with its very similar spec and much lower price. It has the same 8.2 billion transistor 601mm² GM200 core as the Titan X, and a hardware specification that's been reduced in a few areas, but the overall differences are slim. It retains the Titan X's six GPXs, but loses two SMs, resulting in a total of 2,816 stream processors. The number of tessellation units has dropped from 24 to 22, and there are 176 TMUs, down from 192 in the Titan. However, the 96 ROPs are retained, and the 1000MHz base clock (1075MHz boost) is the same.

The other obvious difference is that the GDDR5 video memory has been halved from 12GB to 6GB, but that's unlikely to have much effect on gaming performance at the moment. The memory also runs at the same 1.75GHz clock frequency (7GHz effective) as the Titan X, across a 384-bit bus, giving you a juicy 336GB/sec of memory bandwidth.

The Titan X's trump card is its ability to play games at 4K at solid frame rates, but in our benchmarks, the GTX 980 Ti offers the same benefit. Of all the tests, Crysis 3 is the most demanding, but the 980 Ti matches the Titan exactly with its 28fps minimum. In the other games, the GTX 980 Ti sails past 30fps at 4K. For sure, the Titan is faster at 4K, but the gap is just 2-3fps, which is hardly worth the extra £350. The 980 Ti again matches the Titan X's performance at lower resolutions too.

Meanwhile, AMD's Fury X, which fits into the same price bracket as the 980 Ti, generally doesn't quite match its performance. The GTX 980 Ti's stuttering in GTA V at 1080p is the notable exception, which is likely down to a driver issue, but you don't buy a £530 card for 1080p gaming now anyway. In tests, the 980Ti takes the lead, both in terms of playability and frame rates in general.

Also, while the Fury X is more efficient card than the R9 390, the power draw of the 980 Ti is lower still.

Conclusion

The GTX 980 Ti doesn't offer the great bang per buck of the GTX 970, but if you're looking to play games at 4K without a multi-GPU setup, the GTX 980 Ti handles 4K gaming almost as well as the Titan X, but without the ridiculous price.

1920 SPEED	2560 SPEED	3840 SPEED
23/25	14/15	7/10

VALUE	EFFICIENCY
22/40	8/10

VERDICT

If you want 4K gaming on a single GPU then buy the GeForce GTX 980 Ti.

OVERALL SCORE **74%**

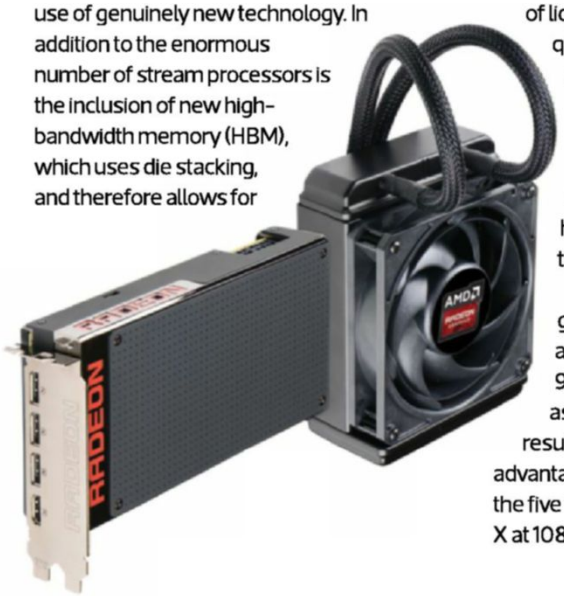
AMD Radeon R9 Fury X 4GB / £500 inc VAT

SUPPLIER www.novatech.co.uk

The Fuji GPU used in AMD's top-of-the-line Fury X takes the company's aging Hawaii core, and soups it up with more of everything. A lot more. It's a very large GPU, based on the Graphics Core Next 1.2 architecture, measuring 596mm^2 and containing a massive count of 8.9 billion transistors, a huge increase from the 6.2 billion in the 438mm^2 Hawaii core.

It has eight Asynchronous Compute Engines (ACE) with four shader engines, each of which has a rasteriser, a geometry processor and 16 compute units, an increase from the 11 in Hawaii. With each compute unit subdividing into 16 stream processors, you get a grand total to 4,096 stream processors – that's more than any other graphics card on test, and a massive increase from the 2,816 stream processors in the Hawaii-based Radeon R9 390X.

Regardless of its performance, the Radeon R9 Fury X is also very interesting due to its use of genuinely new technology. In addition to the enormous number of stream processors is the inclusion of new high-bandwidth memory (HBM), which uses die stacking, and therefore allows for much higher memory bandwidth and lower power consumption, via a ludicrously wide 4,096-bit memory bus. HBM's smaller footprint also means it can be mounted on the GPU package, saving the need for multiple, large GDDR5 chips on the PCB, and resulting in the Fury X being much smaller than your average graphics card. The HBM on the Fury X runs at a lower clock speed than most GDDR5 memory, at 500MHz (1GHz effective), but the super-wide memory interface results in 512GB/sec of memory bandwidth, a big step up from GDDR5 cards.



> The Fury X is notable for its use of liquid cooling as standard

Also, the Fury X is also notable for its use of liquid cooling as standard. Usually, the quality of the cooler depends on a card's manufacturer, but liquid cooling is part of the reference specification of the Fury X, and it's the only single-GPU card to include it as standard. As such, you'll need to make sure you have a free fan mount in order to install the cooler's single-fan radiator.

Regardless of the technology, gaming performance is what counts, and in this respect, the GeForce GTX 980 Ti is the green team's counterpart, as it's so closely priced. From our results, Nvidia has the performance advantage at sub-4K resolution. In four out of the five tests, the 980 Ti outperforms the Fury X at 1080p, GTA V being the only exception, where the GTX 980 Ti and Titan X struggle, probably due to a driver issue. Nvidia has the advantage in all the tests at 2,560 x 1,440 too – in some cases, the gap between the two cards is 5-6fps, but in others it's a double-digit advantage.

However, at 4K it looks a little different. The 980 Ti and Fury X achieve identical results in three of the tests, but the 980 Ti has a 3fps advantage in GTA V and The Witcher III. The difference between the two cards when it comes to power consumption cements the conclusion that Nvidia's high-end card is a better choice, although AMD's Fuji-based Fury cards are considerably more efficient than the Hawaii models, thanks to the use of HBM.

Conclusion

Both AMD and Nvidia's top-end cards are notable for their great performance, with both cards offering great 2,560 x 1,440 performance and playable frame rates even at 4K. It's a close battle, and it's great to see the benefits of HBM on the Fury X, but the 980 Ti still takes the lead in the majority of tests, making it our 4K card of choice.

1920 SPEED	2560 SPEED	3840 SPEED
24/25	13/15	7/10

VALUE	EFFICIENCY
21/40	7/10

VERDICT

Solid 4K performance, but it's beaten by the GeForce GTX 980 Ti in this league.

OVERALL SCORE 72%

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PHILIPS

www.philips.com/lcdmonitors

MISCO.co.uk ebuyer.com BT Business Direct

Nvidia GeForce Titan X 12GB / £793 inc VAT

SUPPLIER www.cclonline.com

Until fairly recently, each generation of Nvidia's top-end GPUs followed a fairly predictable pattern. The launch would start with a single high-end model, followed by a card that squeezed two high-end GPUs into a single power-hungry, wallet-busting package. However, the firm recently ditched the idea of making its flagship graphics card a miniature SLI setup, instead launching a superfast single-GPU card. The Titan X is the latest such card, following on from the GTX 980, but coming out a couple of months before the very similarly specified GTX 980 Ti.

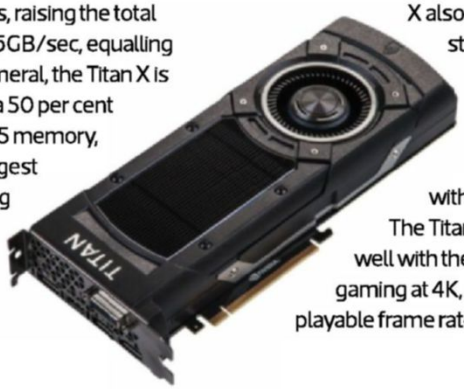
The Titan X is based on Nvidia's GM200 core, with a 601mm^2 die and 8 billion transistors. There are also six graphics processing clusters, each with four streaming multiprocessors, bringing the total to 24, making for a total of 3,072 stream processors, an increase of 50 per cent over the GM204 core in the GTX 980.

The number of texture units has seen the same 50 per cent increase to 192 as well, and there are now 24 tessellation units, 96 ROPs and a 384-bit memory bus, raising the total memory bandwidth to 336GB/sec, equalling the older GTX 780 Ti. In general, the Titan X is like the GTX 980 but with a 50 per cent boost. With 12GB of GDDR5 memory, the Titan X also has the largest frame buffer of any gaming GPU on the market. That's triple the memory capacity offered by a standard GTX 980, and twice the amount you get in the GTX 980 Ti.

As you would expect, though, this hardware comes at a high price. At £793 inc VAT, Nvidia's top-of-the-line GPU costs around £300 more than the next most expensive card, AMD's Radeon R9 Fury X, and £320 more than the GeForce GTX 980Ti. Should you choose to invest in one, it's likely to be the most expensive component in your PC.

> The Titan X is like the GTX 980 but with a 50 per cent boost

For your money, you of course get a very capable graphics card. The Titan X outperforms every other card on test, consistently staying above 60fps in every test at 2,560 x 1,440 – it only faltered in Crysis 3, but even then the 59fps minimum is a cracking result. Like the GTX 980 Ti, the Titan X also struggled with stuttering issues in GTA V at 1080p, but you're very unlikely to be playing at 1080p with this card anyway. The Titan X even copes well with the demands of gaming at 4K, managing playable frame rates in each test.



The performance difference between the Titan X and the other less expensive top tier graphics cards is very slim – the difference isn't even in double digits. In fact, the difference in 4K minimum frame rates between the Titan X and GTX 980 Ti is generally only 2fps, peaking at 4fps. Expensive cards justify their price if you get a lot more performance, but you get severely diminishing returns once you get past the GeForce GTX 980 Ti and Radeon R9 Fury X.

Conclusion

While the Titan X is certainly the fastest graphics card around, it isn't much faster than the next tier of GPUs, which cost considerably less money. As such, it offers terrible value for money, and it's only really worth choosing for bragging rights. Indeed, the GTX 980 Ti shares much of the same specification, albeit with less GDDR 5 memory, but that doesn't prevent it from offering similar performance at 4K for a lot less cash.

1920 SPEED	2560 SPEED	3840 SPEED
23/25	14/15	7/10

VALUE	EFFICIENCY
14/40	8/10

VERDICT

Don't bother with the expense – the GTX 980 Ti offers nearly the same speed for far less money.

OVERALL SCORE 66%

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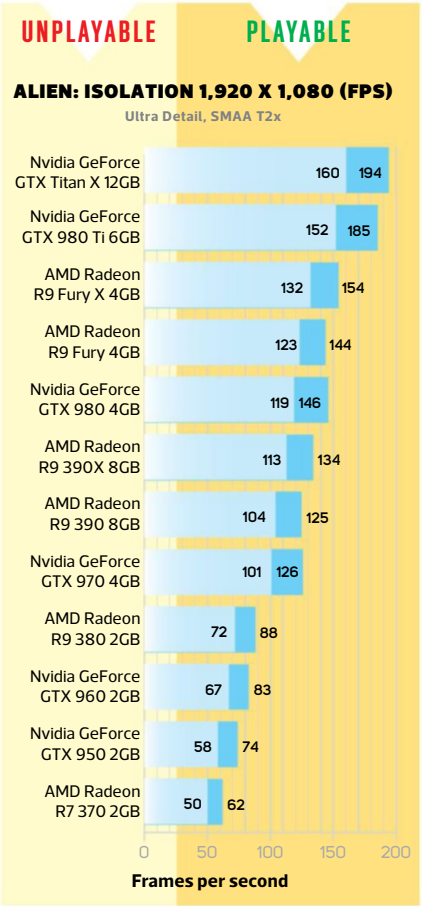
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PLAYABLE
ALIEN: ISOLATION 1,920 X 1,080 (FPS)
Ultra Detail, SMAA T2x
Nvidia GeForce GTX Titan X 12GB 160 194
Nvidia GeForce GTX 980 Ti 6GB 152 185
AMD Radeon R9 Fury X 4GB 132 154
AMD Radeon R9 Fury 4GB 123 144
Nvidia GeForce GTX 980 4GB 119 146
AMD Radeon R9 390X 8GB 113 134
AMD Radeon R9 390 8GB 104 125
Nvidia GeForce GTX 970 4GB 101 126
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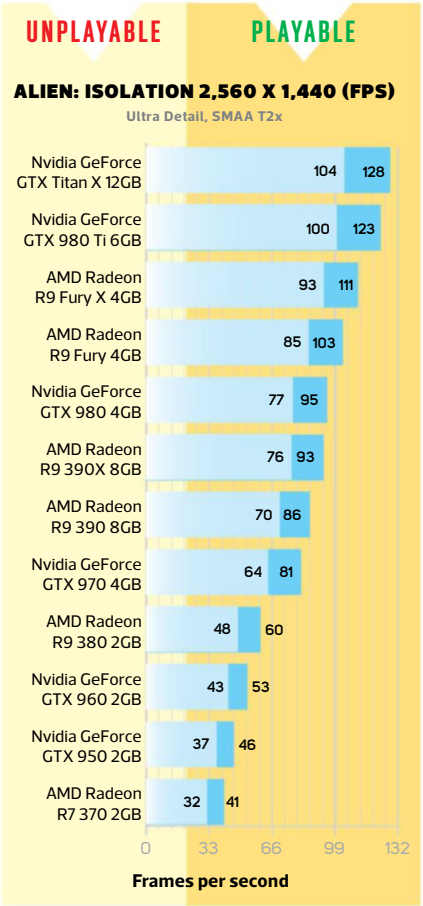
Frames per second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Ultra Detail, SMAA T2x
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Nvidia GeForce GTX 980 Ti 6GB 100 123
AMD Radeon R9 Fury X 4GB 93 111
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AMD Radeon R9 390X 8GB 76 93
AMD Radeon R9 390 8GB 70 86
Nvidia GeForce GTX 970 4GB 64 81
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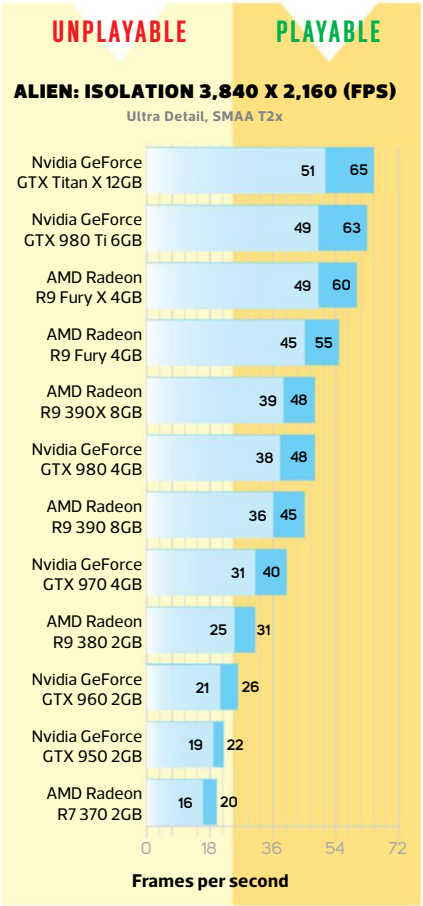
Nvidia GeForce GTX 950 2GB 37 46
AMD Radeon R7 370 2GB 32 41
0 33 66 99 132
Frames per second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PLAYABLE
ALIEN: ISOLATION 3,840 X 2,160 (FPS)
Ultra Detail, SMAA T2x
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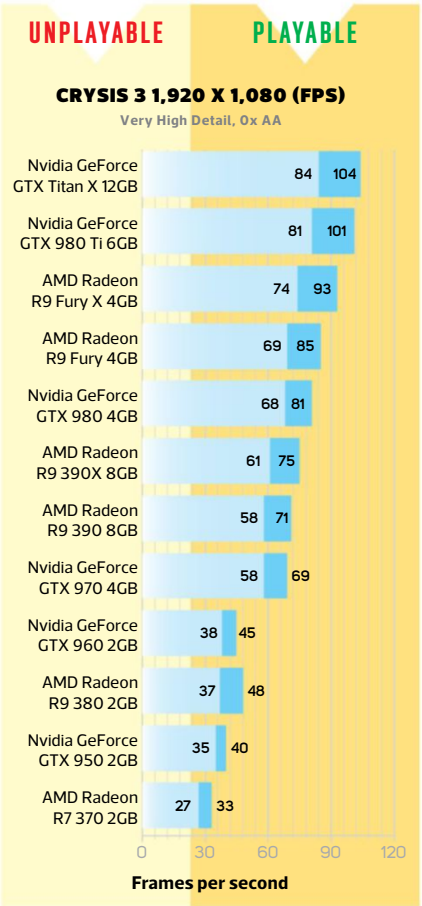
Nvidia GeForce GTX 980 Ti 6GB 49 63
AMD Radeon R9 Fury X 4GB 49 60
AMD Radeon R9 Fury 4GB 45 55
AMD Radeon R9 390X 8GB 39 48
Nvidia GeForce GTX 980 4GB 38 48
AMD Radeon R9 390 8GB 36 45
Nvidia GeForce GTX 970 4GB 31 40
AMD Radeon R9 380 2GB 25 31
Nvidia GeForce GTX 960 2GB 21 26
Nvidia GeForce GTX 950 2GB 19 22
AMD Radeon R7 370 2GB 16 20
0 18 36 54 72
Frames per second


UNPLAYABLE
PLAYABLE
CRYSIS 3 1,920 X 1,080 (FPS)
Very High Detail, 0x AA
Nvidia GeForce GTX Titan X 12GB 84 104
Nvidia GeForce GTX 980 Ti 6GB 81 101
AMD Radeon R9 Fury X 4GB 74 93
AMD Radeon R9 Fury 4GB 69 85
Nvidia GeForce GTX 980 4GB 68 81
AMD Radeon R9 390X 8GB 61 75
AMD Radeon R9 390 8GB 58 71
Nvidia GeForce GTX 970 4GB 58 69
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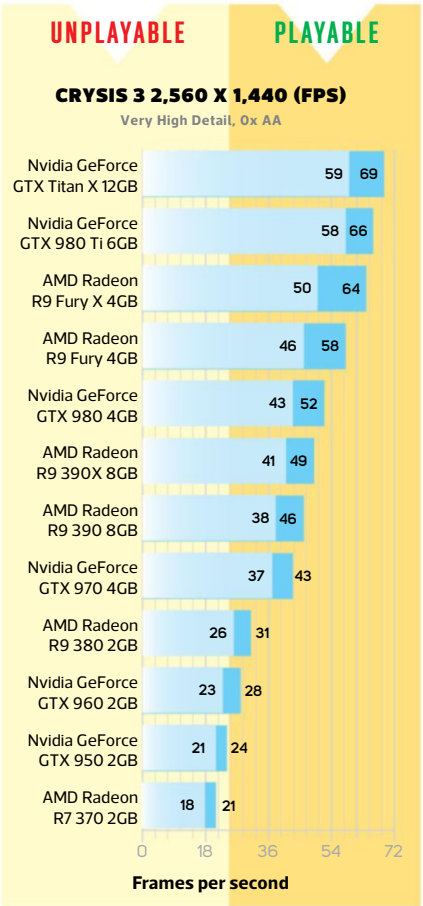
Frames per second


UNPLAYABLE
PLAYABLE
CRYSIS 3 2,560 X 1,440 (FPS)
Very High Detail, 0x AA
Nvidia GeForce GTX Titan X 12GB 59 69
Nvidia GeForce GTX 980 Ti 6GB 58 66
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AMD Radeon R9 Fury 4GB 46 58
Nvidia GeForce GTX 980 4GB 43 52
AMD Radeon R9 390X 8GB 41 49
AMD Radeon R9 390 8GB 38 46
Nvidia GeForce GTX 970 4GB 37 43
AMD Radeon R9 380 2GB 26 31
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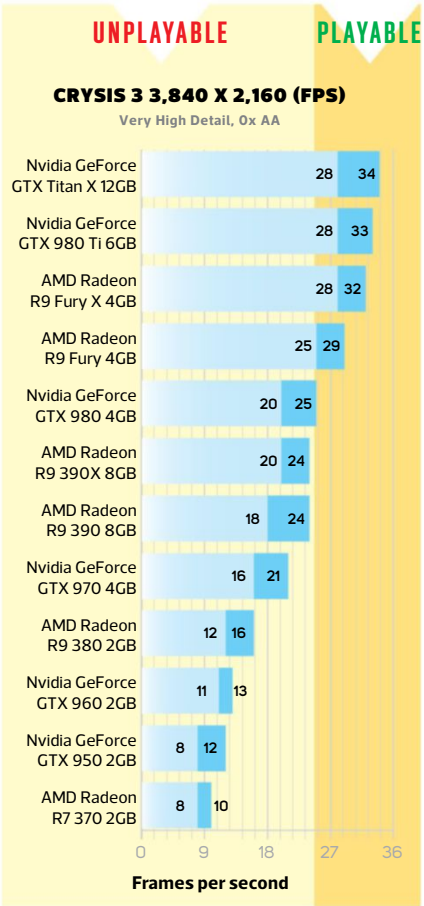
AMD Radeon R7 370 2GB 18 21
0 18 36 54 72
Frames per second


UNPLAYABLE
PLAYABLE
CRYSIS 3 3,840 X 2,160 (FPS)
Very High Detail, 0x AA
Nvidia GeForce GTX Titan X 12GB 28 34
Nvidia GeForce GTX 980 Ti 6GB 28 33
AMD Radeon R9 Fury X 4GB 28 32
AMD Radeon R9 Fury 4GB 25 29
Nvidia GeForce GTX 980 4GB 20 25
AMD Radeon R9 390X 8GB 20 24
AMD Radeon R9 390 8GB 18 24
Nvidia GeForce GTX 970 4GB 16 21
AMD Radeon R9 380 2GB 12 16
Nvidia GeForce GTX 960 2GB 11 13
Nvidia GeForce GTX 950 2GB 8 12
AMD Radeon R7 370 2GB 8 10
0 9 18 27 36
Frames per second

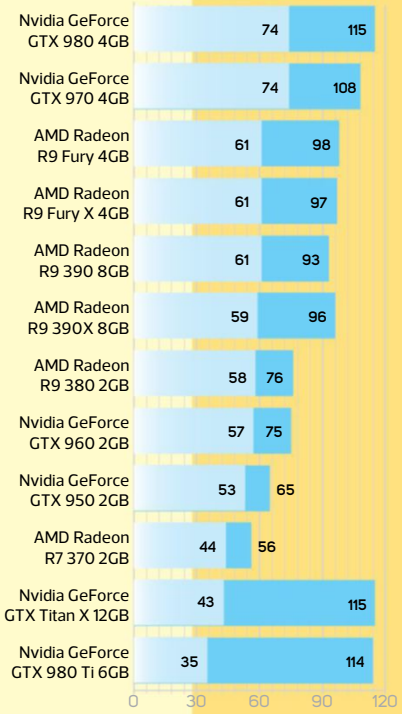
Minimum
Average

Minimum
Average

UNPLAYABLE PLAYABLE

GRAND THEFT AUTO V 1,920 X 1,080 (FPS)

Very High Detail, FXAA

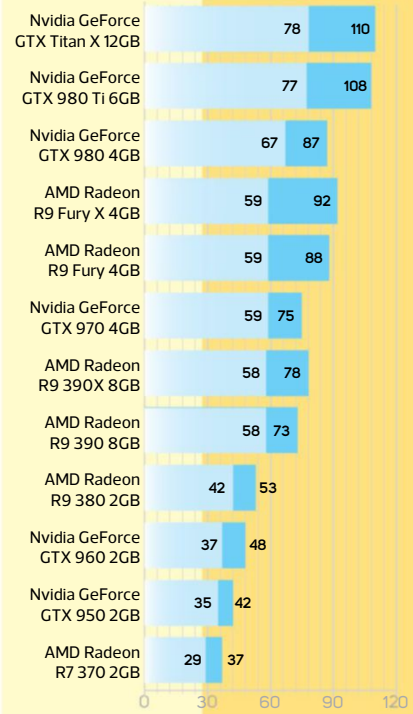


Frames per second

UNPLAYABLE PLAYABLE

GRAND THEFT AUTO V 2,560 X 1,440 (FPS)

Very High Detail, FXAA

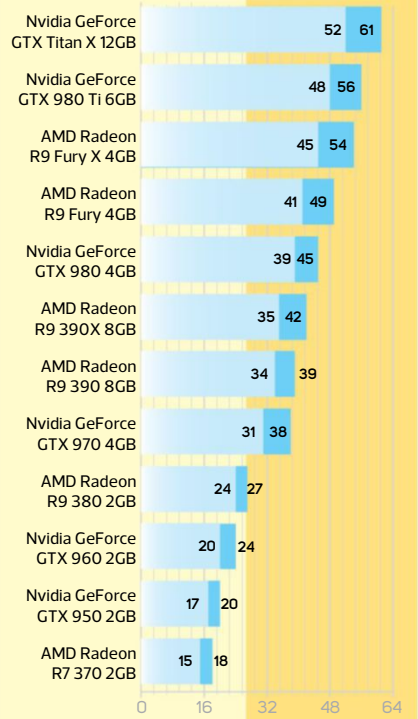


Frames per second

UNPLAYABLE PLAYABLE

GRAND THEFT AUTO V 3,840 X 2,160 (FPS)

Very High Detail, FXAA



Frames per second

Minimum Average

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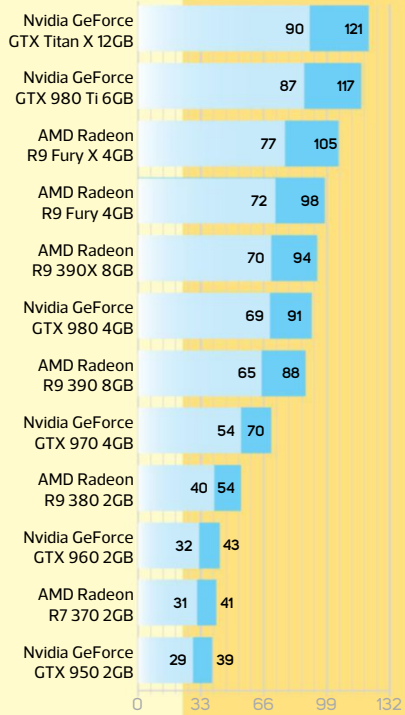
MIDDLE EARTH: SHADOW OF MORDOR 1,920 X 1,080 (FPS)

Ultra Detail



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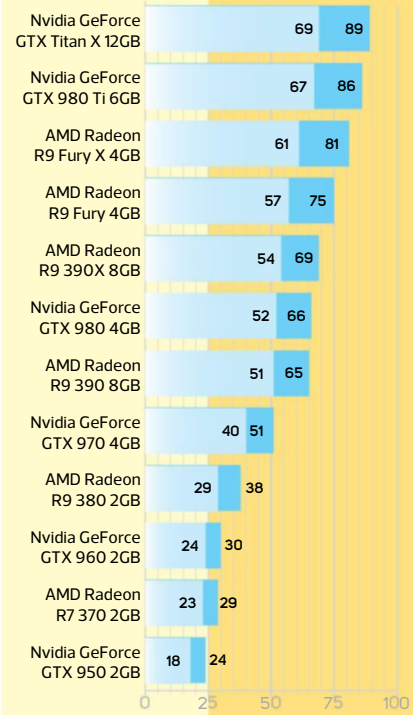
MIDDLE EARTH: SHADOW OF MORDOR 2,560 X 1,440 (FPS)

Ultra Detail

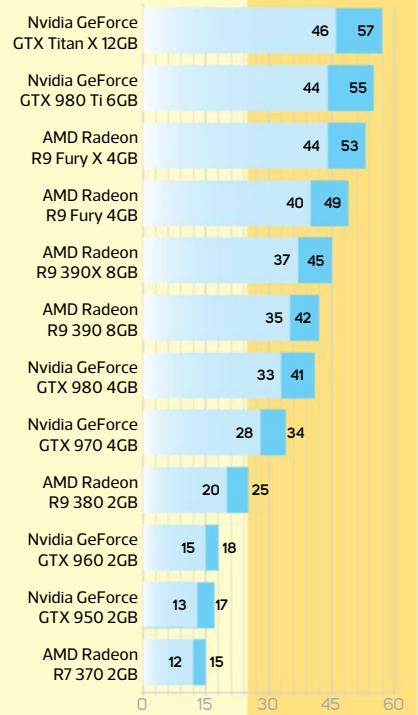


Frames per second

UNPLAYABLE PLAYABLE

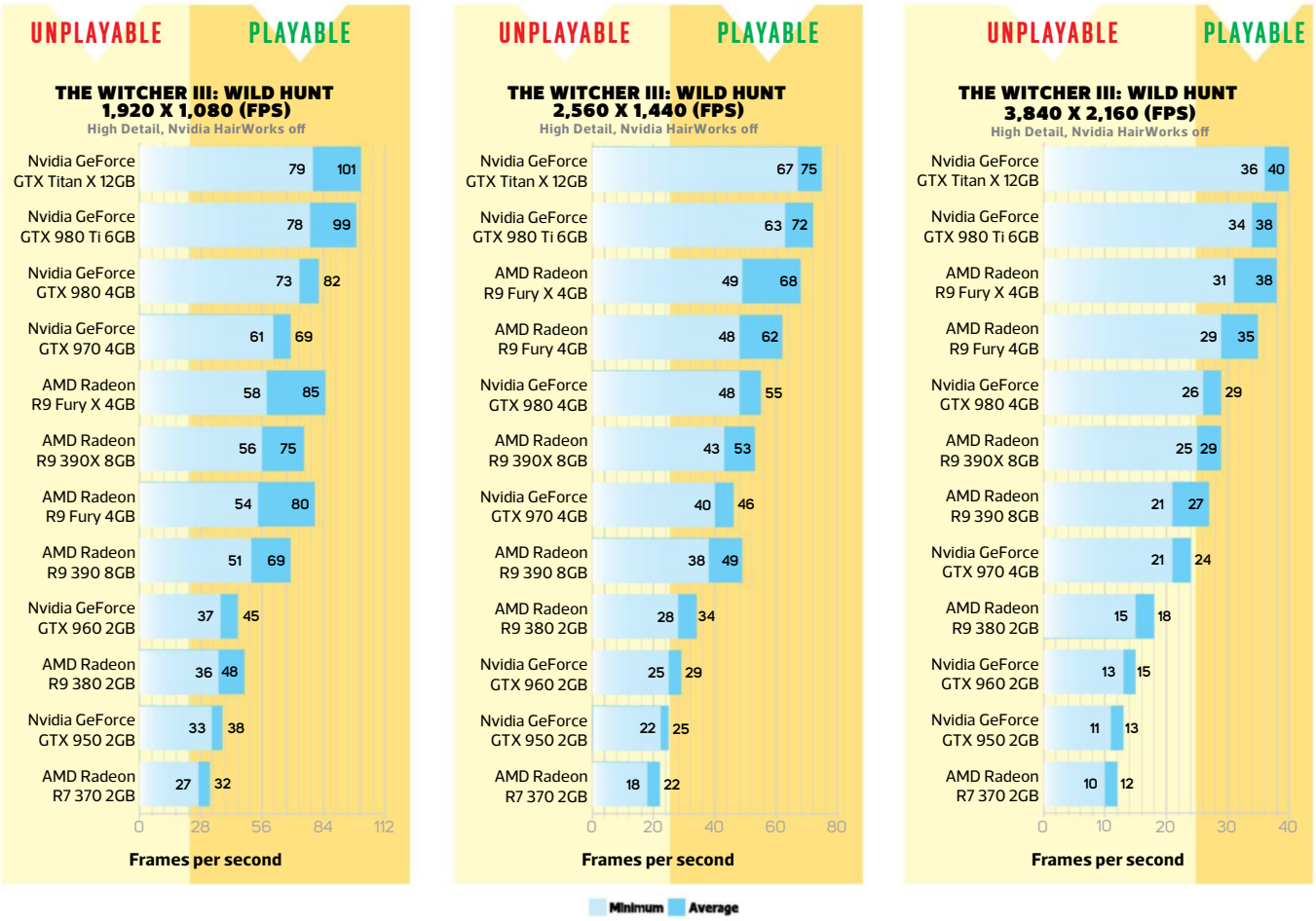
MIDDLE EARTH: SHADOW OF MORDOR 3,840 X 2,160 (FPS)

Very High Detail



Frames per second

Minimum Average


UNPLAYABLE
PLAYABLE
THE WITCHER III: WILD HUNT
1,920 X 1,080 (FPS)
High Detail, Nvidia HairWorks off
Nvidia GeForce GTX Titan X 12GB 79 101
Nvidia GeForce GTX 980 Ti 6GB 78 99
Nvidia GeForce GTX 980 4GB 73 82
Nvidia GeForce GTX 970 4GB 61 69
AMD Radeon R9 Fury X 4GB 58 85
AMD Radeon R9 390X 8GB 56 75
AMD Radeon R9 Fury 4GB 54 80
AMD Radeon R9 390 8GB 51 69
Nvidia GeForce GTX 960 2GB 37 45
AMD Radeon R9 380 2GB 36 48
Nvidia GeForce GTX 950 2GB 33 38
AMD Radeon R7 370 2GB 27 32
0 28 56 84 112
Frames per second
UNPLAYABLE
PLAYABLE
THE WITCHER III: WILD HUNT
2,560 X 1,440 (FPS)
High Detail, Nvidia HairWorks off
Nvidia GeForce GTX Titan X 12GB 67 75
Nvidia GeForce GTX 980 Ti 6GB 63 72
AMD Radeon R9 Fury X 4GB 49 68
AMD Radeon R9 Fury 4GB 48 62
Nvidia GeForce GTX 980 4GB 48 55
AMD Radeon R9 390X 8GB 43 53
Nvidia GeForce GTX 970 4GB 40 46
AMD Radeon R9 390 8GB 38 49
AMD Radeon R9 380 2GB 28 34
Nvidia GeForce GTX 960 2GB 25 29
Nvidia GeForce GTX 950 2GB 22 25
AMD Radeon R7 370 2GB 18 22
0 20 40 60 80
Frames per second
UNPLAYABLE
PLAYABLE
THE WITCHER III: WILD HUNT
3,840 X 2,160 (FPS)
High Detail, Nvidia HairWorks off
Nvidia GeForce GTX Titan X 12GB 36 40
Nvidia GeForce GTX 980 Ti 6GB 34 38
AMD Radeon R9 Fury X 4GB 31 38
AMD Radeon R9 Fury 4GB 29 35
Nvidia GeForce GTX 980 4GB 26 29
AMD Radeon R9 390X 8GB 25 29
AMD Radeon R9 390 8GB 21 27
Nvidia GeForce GTX 970 4GB 21 24
AMD Radeon R9 380 2GB 15 18
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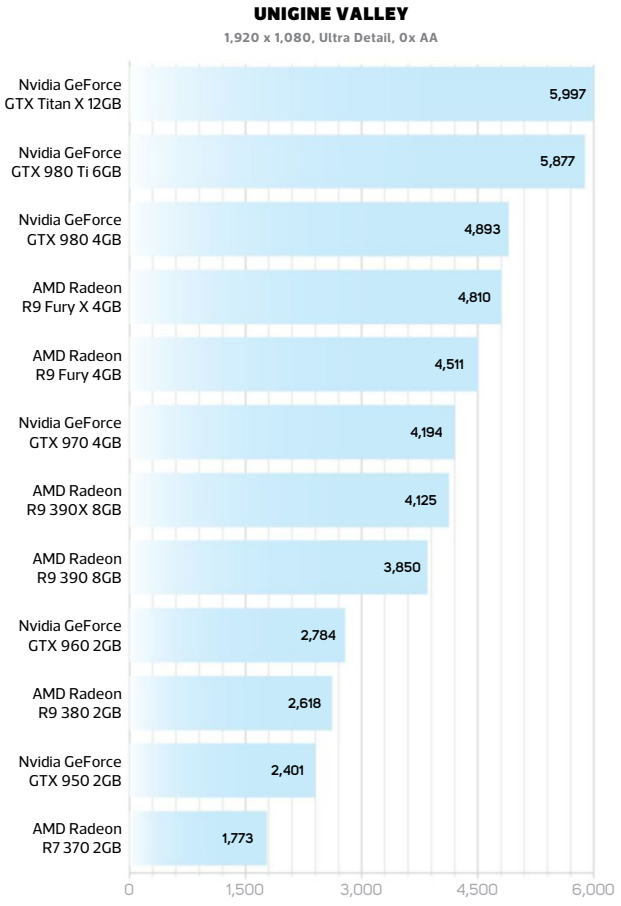
AMD Radeon R7 370 2GB 10 12
0 10 20 30 40
Frames per second
Minimum
Average


UNIGINE VALLEY
1,920 x 1,080, Ultra Detail, 0x AA
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Nvidia GeForce GTX 980 Ti 6GB 5,877
Nvidia GeForce GTX 980 4GB 4,893
AMD Radeon R9 Fury X 4GB 4,810
AMD Radeon R9 Fury 4GB 4,511
Nvidia GeForce GTX 970 4GB 4,194
AMD Radeon R9 390X 8GB 4,125
AMD Radeon R9 390 8GB 3,850
Nvidia GeForce GTX 960 2GB 2,784
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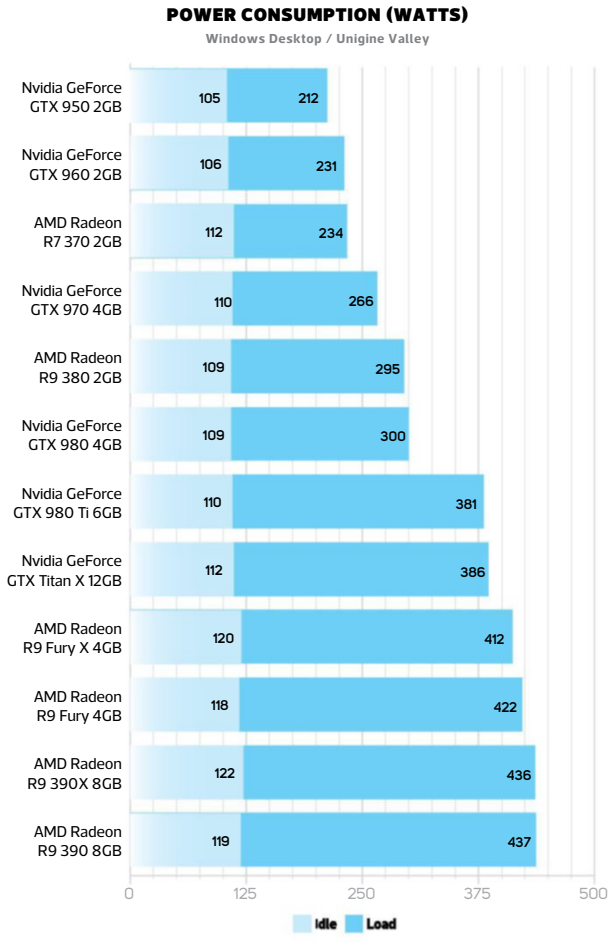
POWER CONSUMPTION (WATTS)
Windows Desktop / Unigine Valley
Nvidia GeForce GTX 950 2GB 105 212
Nvidia GeForce GTX 960 2GB 106 231
AMD Radeon R7 370 2GB 112 234
Nvidia GeForce GTX 970 4GB 110 266
AMD Radeon R9 380 2GB 109 295
Nvidia GeForce GTX 980 4GB 109 300
Nvidia GeForce GTX 980 Ti 6GB 110 381
Nvidia GeForce GTX Titan X 12GB 112 386
AMD Radeon R9 Fury X 4GB 120 412
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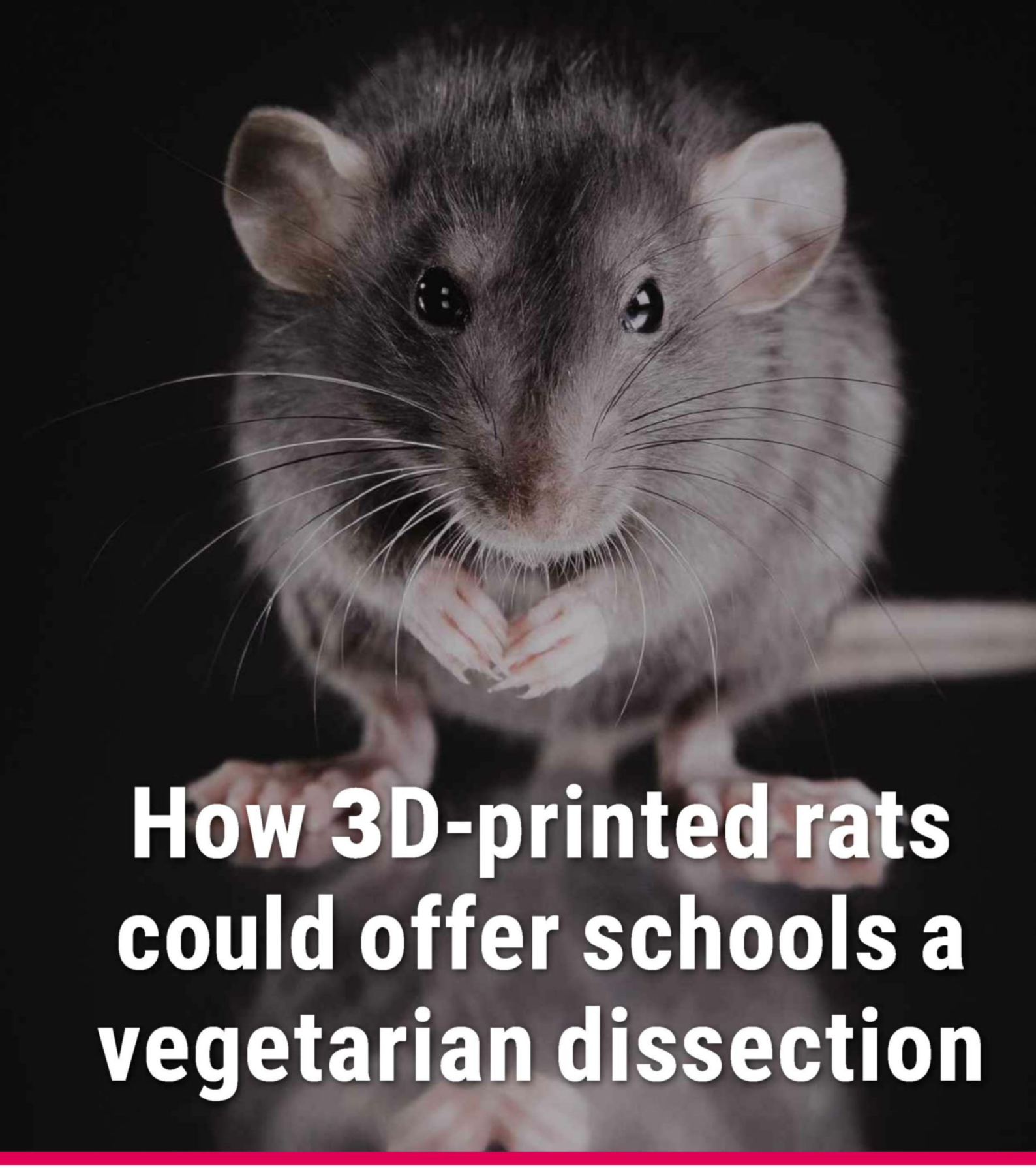
Load



How 3D-printed rats could offer schools a vegetarian dissection

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PC system reviews

GAMING PC

Overclockers Titan Wave / £1,349 inc VAT

SUPPLIER www.overclockers.co.uk

Overclockers' Titan Wave has an appropriate name, being the latest in a surge of recent small form factor machines hoping to blow ATX machines out of the water. It has a 6-core processor and GTX 970 graphics, and it's all crammed inside a Corsair Carbide Air 240 chassis – a dark, brooding lump of metal that subverts a host of familiar issues with clever design.

Storage, for instance, is handled smartly: the trios of hard disk and SSD bays are accessed by removing panels, so their tool-free caddies can slide right out. The motherboard tray divides the case down the middle, with the PSU and cables kept on one side until they emerge through rubber-lined holes. Every side panel can be removed, which makes access easier than on many small form factor builds too.

The Carbide looks impressive as well. Most of its surfaces are matt, with angles and lines that make it look like a piece of military hardware rather than a PC enclosure. One side panel has a full-sized window too, showing off the tidy build and blue LEDs that ring the interior. Build quality is top-quality too: the side panels are strong, and the chassis is built around a rigid metal skeleton. This hard-wearing case will stand up to the rigours of the road.

The Carbide's extra width means it isn't as small as some micro-ATX chassis, but its rubber feet can be repositioned, so you can reorientate the system. Also, unlike much smaller systems, such as the Chillblast Fusion Nano (see Issue 147, p56), the Titan Wave is more versatile, with room to upgrade.

Overclockers has also crammed some serious hardware into the Titan Wave. The Core i7-5820K is a 6-core Haswell-E processor that's usually clocked at 3.3GHz, but Overclockers has pumped 1.2V through the vcore to overclock the chip to 4GHz. Meanwhile, the GeForce GTX 970 graphics card is a collaboration between Nvidia board partner KFA^2 and some help from champion overclocker 8Pack. The original card was overclocked from 1050MHz to 1164MHz, but Overclockers has upped the clock to 1178MHz, which means a boost clock of 1329MHz.

There's also 16GB of 2400MHz DDR4 memory, and storage comes from a 250GB Samsung 850 EVO SSD and a 2TB hard disk, which covers all your bases. The SSD is fine, but the Gigabyte GA-X99M Gaming 5 motherboard has two M.2 slots, with one that can be used for full-speed PCI-E SSDs that easily outperform SATA drives, and it's disappointing that neither of them have been used.

The motherboard also has two 16x PCI-E slots free, and there are enough PCI-E lanes free to set up a dual-GPU SLI rig – the second PCI-E slot can only use eight lanes, as the Core i7-5820K only has 28 lanes in total, but that's still ample bandwidth for a second GTX 970.

The motherboard also crams in plenty of features, despite its micro-ATX form factor. It has Killer Networking, a SATA Express port alongside six vacant SATA 6Gbps connectors, on-board power, reset and clear-CMOS buttons, and a POST error display. The rear I/O is a little disappointing though: it has more USB 2 ports than USB 3 ports, and its two PS/2 ports are a waste of space for most people today too.

Some significant cooling gear is installed as well. The processor is chilled by an OCUK Tech Labs Raijintek liquid cooler with a 240mm radiator and four 120mm fans. Two more 120mm fans sit at the top of the case to act as exhausts, and the graphics card has a pair of 90mm units. That's ample cooling hardware for such a small PC.

Finally, there's a three-year warranty that includes a year of parts and labour coverage and two years of collect-and-return service, which is a decent enough deal.

Performance

The Core i7-5820K processor inside the Titan Wave is a formidable CPU, providing six physical cores for storming multi-threaded performance. The Titan Wave's overclock also means it's no slouch in single-threaded apps, with its score of 57,273 in our Gimp test still being competitive. Skylake systems are quicker in this test, but it's fast enough for most people's needs.

/SPECIFICATIONS

CPU 3.3GHz Intel Core i7-5820K overclocked to 4GHz

Motherboard Gigabyte GA-X99M Gaming 5

Memory 16GB Team Group Elite Plus 2400MHz DDR4

Graphics KFA^2 GeForce GTX 970 4GB

Storage 250GB Samsung 850 Evo SSD, 2TB Seagate Barracuda hard disk

Case Corsair Carbide Air 240

Cooling CPU: OCUK Tech Labs Liquid Cooler with 4 x 120mm fans; GPU: 2 x 90mm fans; top: 2 x 120mm fans

PSU SuperFlower HX 650W

Ports Front: 2 x USB 3, 2 x audio; rear: 4 x USB 3, 6 x USB 2, 2 x PS/2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Windows 10 64-bit

Warranty Three years collect and return with parts and labour covered, plus one year return to base labour only

The Titan Wave's muscular silicon really proved its worth in our heavily multi-threaded H.264 video encoding test, though, with a superb score of 364,000, beating the 320,046 from the aforementioned Skylake-based Chillblast Fusion Nano. The end result was a great system score of 154,777, showing that this system has enough grunt for almost any job, although it's also overkill for the vast majority of games and computing tasks. That's also a superior result to the 140,640 from the Overclockers Titan Riptide (see Issue 146, p68), which had a similar spec but fell behind in our single-threaded image editing test.

The Titan Wave's overclocked GTX 970 card proved adept with games at 2,560 x 1,440 too, never dropping below 30fps in any of our tests. Meanwhile, Samsung SSD ran through our sequential read and write tests at 514MB/sec and 496MB/sec. That's fast for a SATA SSD, but it's unable to compete with the 1,764MB/sec and 1,196MB/sec clocked up by the Chillblast's M.2 PCI-E SSD.

The Titan Wave's bigger issue is noise. When idle, it produced an obvious low rumble, and that noise increased during game tests. It isn't ruinous, especially if you're playing games with speakers or are in a room full of other PCs, but it's louder than most ATX gaming systems. On the plus side, the internals are kept cool, with fine CPU and GPU delta Ts of 39°C and 50°C respectively.

Conclusion

The Overclockers Titan Wave has a well-designed, sturdy enclosure that's more accessible and versatile than many small form factor cases. The CPU and graphics card are also fast and there's plenty of memory and storage. However, while the aforementioned Overclockers Titan Riptide may be a little slower, it's notably cheaper and otherwise has a similar spec – even upgrading it to a 250GB SSD only brings up the price to £1,253 inc VAT. The extra money for the Titan Wave effectively buys you an overclock on the GTX 970, a liquid cooler and the Corsair micro-ATX chassis. They're all decent features, but they arguably don't justify the extra outlay, especially when you consider the Titan Wave's noise.

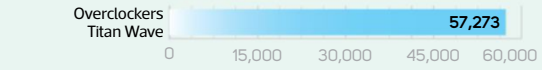
The Titan Wave is a well-built, fast and versatile micro-ATX system with some great parts, but its comparatively loud noise and slight premium over a comparable ATX rig means it just falls short of a recommendation.

MIKE JENNINGS

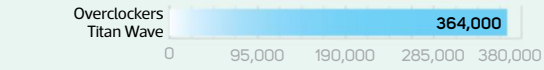
1. **The liquid cooler's radiator has four fans attached to it**
2. **The KFA² GTX 970 card has been tweaked by 8Pack**
3. **The Core i7-5820K is overclocked to 4GHz**

CPC REALBENCH 2015

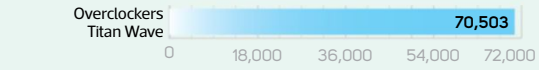
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING



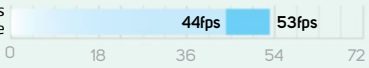
LUXMARK OPENCL



HEAVY MULTITASKING

BATTLEFIELD 4

2,560 x 1,440, Ultra Detail, 4x AA

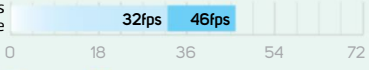


MIDDLE EARTH: THE SHADOW OF MORDOR

2,560 x 1,440, Ultra Detail, FXAA

CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



Minimum Average

SYSTEM SCORE

INTEL REFERENCE: 135.23%

SPEED	DESIGN
22/25	22/25
HARDWARE	**VALUE**
21/25	21/25

OVERALL SCORE 86%

VERDICT

An impressively versatile chassis, decent build quality and fast performance, but it's a little too loud, and you can buy a similar spec for less money.

HIGH-END GAMING PC

Scan 3XS X99 Carbon Extreme SLI / £4,799 inc VAT

SUPPLIER www.scan.co.uk

Scan has frequently been a big hit in our Dream PC Labs, where it mixes benchmark-wrecking hardware with stunning, customised builds. Its recent effort, the Barracuda, took home this year's top prize. The firm's 3XS X99 Carbon Extreme SLI isn't a Dream PC, but it's not far off. Scan has taken its Barracuda blueprint, kept most of the components and ditched the customisation to drop the price from £9,499 to just £4,799 inc VAT.

That's a massive saving on a mighty specification. For starters, there are three GeForce GTX 980 Ti graphics cards, each with various tweaks. The three EVGA cards left the factory with cores overclocked from 1000MHz to 1102MHz, and Scan has improved that to 1150MHz. Likewise, EVGA left the memory at its stock speed of 7010MHz, but the 3XS team has upped it to 7310MHz.

The numbers involved are staggering. The GPUs share 18GB of memory, 24 billion transistors and 8,448 stream processors. Those clocks are only a little lower than those of the Barracuda's cards, and three cards is one more than any of the entries into the high-end Dream PCs category this year.

Meanwhile, the Core i7-5960X is Intel's top consumer chip, with eight cores, 20MB of L3 cache and the full complement of 40 PCI-E 3 lanes. Scan has pumped 1.312V through the chip with a 125MHz base clock and a 36x multiplier to raise the core from 3.3GHz to 4.5GHz, which is barely slower than the Barracuda's 4.625GHz speed. The CPU sits alongside 32GB of Corsair 2666MHz DDR4 memory. There's no sign of a hard disk, but you're unlikely to need one – the boot drive is a 512GB Samsung SM951 M.2 SSD, and the secondary drive is a 1TB Samsung 850 Evo SSD.

The Asus X99-S motherboard has numerous bells and whistles too. The M.2 SSD is installed in a perpendicular socket that offers the full complement of four PCI-E 3 lanes. The board also has SATA Express, on-board power and reset buttons, a POST display and BIOS switches.

Plus, while Scan has cut back on customisation to reduce the price of this machine, but that doesn't mean the Carbon Extreme looks dull. Central to the system is the mighty loop that keeps the GPUs chilled. An EK Res X3 reservoir sits in the middle of the chassis feeding coolant to the cards, and it's paired with a 280mm radiator that sits in the front. Meanwhile, the CPU is cooled by an EK Supremacy EVO waterblock linked to a 360mm EK Coolstream radiator in the top of the chassis.

Both loops are filled with white coolant from a tall cylindrical reservoir, which is a bright point in this smart, moody interior – the waterblocks, tubing and PSU cables are all black, as is the memory.

The monochrome theme remains prevalent on the outside. The Corsair Graphite 760T case's front is made from dark plastic and metal, with a meshed panel that pops away to reveal two 140mm fans, while the top is made from white metal. Both side panels swing open on hinges rather than lift away with thumbscrews, and the whole unit sits on chunky black feet.

Scan has done an impeccable job with the build too. The power and SATA cables are barely visible behind the neat water-cooling gear, and it's no less impressive at the rear, where cables run in rigid lines and are kept tied down.

The warranty is a good deal too, with both parts and labour covered for three years, including a year of on-site coverage.

/SPECIFICATIONS

CPU 3.3GHz Intel Core i7-5960X overclocked to 4.5GHz

Motherboard Asus X99-S

Memory 32GB Corsair Vengeance LPX 2666MHz DDR4

Graphics 3 x EVGA GeForce GTX 980 Ti 6GB

Storage 512GB Samsung SM951 M.2 SSD, 1TB Samsung 850 Evo SSD

Case Corsair Graphite Series 760T V2

Cooling CPU: EK Supremacy EVO waterblock, 360mm EK Coolstream PE radiator, 3 x 120mm Corsair fans; GPU: 3 x EK FC Titan X waterblocks, 280mm EK Coolstream CE radiator, 2 x 120mm fans; front: 2 x 140mm Corsair fans; rear: 1 x 140mm Corsair fan

PSU Corsair HX1200i

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 8 x USB 3, 2 x USB 2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Windows 10 Home 64-bit

Warranty Three years parts and labour, with one year on site and two years return to base

Performance

The trio of graphics cards blasted through our 4K benchmarks, staying well above 60fps in every single test. Its slowest minimum frame rate came was in Crysis 3, but even then, the result was an incredible minimum of 83fps. Comparatively, the pricier Overclockers Infin8 Emperor (see Issue 145, p44) returned minimums of 78fps and 54fps in Battlefield and Crysis

The trio of graphics cards bats aside dual-GPU rivals, and the overclocked processor was no less impressive, with scores close to Dream PC rivals. The Scan's video encoding result of 520,515 is miles ahead of the £3,999 Scan 3XS Cyclone with its 6-core CPU, which scored just 406,190, and it's only around 15,000 points behind the aforementioned Overclockers machine. The Scan's overall system score of 209,612 is a great result. The Overclockers Infin8 Emperor has the edge in these tests, with a system score of 535,393, thanks to 8Pack's overclocking expertise, but the Scan is still a very powerful machine.

Meanwhile, the Samsung M.2 SSD's sequential read and write scores of 1,827MB/sec and 1,496MB/sec are superb results, and the 1TB 6Gbps 850 Evo managed 507MB/sec and 489MB/sec – far faster than a traditional hard disk.

ELITE
NEW ENTRY
P68

1 **The three EVGA GTX 980 Ti cards made mincemeat of our game tests**

2 **The tall reservoir is filled with white coolant, and it supplies both loops**

3 **The water-cooled Core i7-5960X CPU is overclocked to 4.5GHz**

Our standard stress test involves Prime95 and Unigine Heaven, during which water-cooled GTX 980 Tis barely broke a sweat – their top delta T of 28°C is fantastic. The processor's delta T of 63°C is higher, thanks to its eight overclocked cores, but it's still within specification and no cause for worry. The Scan's peak power consumption, meanwhile, topped out at 997W, pushing the 1200W Corsair HXi PSU hard.

Amazingly, thanks to the expertly tweaked water-cooling loop, the Carbon Extreme SLI is also very quiet. Its noise remains subtle during less intensive tasks, and only increases a little during tougher games and tests. It's no louder than the vast majority of gaming PCs we test, despite the colossal amount of high-power hardware inside.

Conclusion

Scan aimed to provide Dream PC-style performance without frills with the Carbon Extreme SLI, and it's delivered. The trio of overclocked graphics card help the Scan's gaming performance to outstrip key rivals by a significant margin, and the processor performance is fantastic too, even if it can't quite catch Overclockers' top-end handiwork.

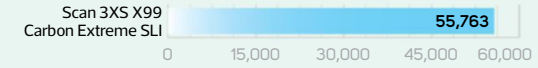
Scan's concentration on performance doesn't mean this PC is ugly or basic either. The Corsair case is excellent, the water-cooling system looks smart and effective, the lighting looks great and noise levels remain reasonable too, even at full load.

The Scan 3XS Carbon Extreme SLI eschews the luxuries found elsewhere in Dream PCs in favour of pure performance, and there's no denying its punch in every category. The Overclockers Infini8 Emperor might look slicker with its acrylic tubing, but the Carbon Extreme is faster in games and £500 cheaper, making it our new premium PC of choice.

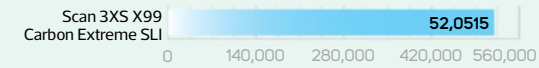
MIKE JENNINGS

CPC REALBENCH 2015

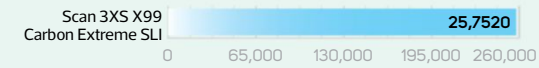
GIMP IMAGE EDITING



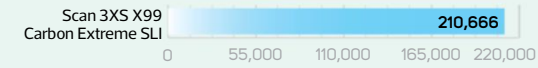
HANDBRAKE H.264 VIDEO ENCODING



LUXMARK OPENCL



HEAVY MULTITASKING

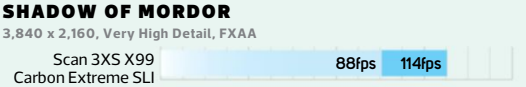


BATTLEFIELD 4

3,840 x 2,160, Ultra Detail, 0x AA

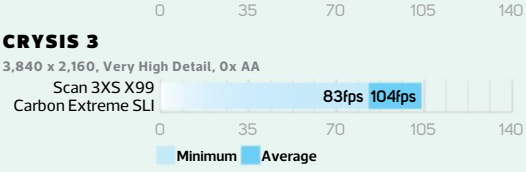
SHADOW OF MORDOR

3,840 x 2,160, Very High Detail, FXAA



CRYSIS 3

3,840 x 2,160, Very High Detail, 0x AA



SYSTEM SCORE

INTEL REFERENCE: 183.14%

SPEED	DESIGN	OVERALL SCORE	VERDICT
24/25	23/25	92%	Incredible gaming speed and a slick, no-nonsense build make this a tempting alternative to flashier Dream PCs.
HARDWARE	VALUE		
24/25	21/25		

HIGH-END GAMING PC

Aria Halo Rampage / £7,500 inc VAT

SUPPLIER www.aria.co.uk

Many retailers offer water-cooled PC these days, and the range of off-the-shelf components is now huge, so building one is easier than ever, even if it can still be a faff. However, it isn't often you see a water-cooling loop as instantly accessible as the one in Aria's Halo Rampage. The company is working in partnership with Thermaltake, which recently delved headfirst into the custom water-cooling scene with a range of its own radiators, fans, pumps and other accessories. It's sure to shake up the market a little, but for now, Aria has used Thermaltake gear for all but the GPU waterblocks system in the Halo Rampage's water-cooling system.

None of the rest of the hardware is Thermaltake-made, though, and the first part you notice is the test bench chassis. Aria has used DimasTech's Easy V3 test bench, which provides a mass of water-cooling support, including mounts for two triple 120mm-fan radiators, pumps and reservoirs. However, Aria also states that this particular system is more of a showcase of its water-cooling skills, and if customers would prefer the hardware to be built into a normal chassis, you would just need to request as much from the sales helpline. In fact, a near-identical system sat next to it, built into a Thermaltake Core X9 case, in Aria's warehouse when we visited the company recently.

That's perhaps just as well – the Halo-Rampage might look gorgeous, but dust is always a problem with open-air cases. It's nothing a Dyson can't fix, of course, plus if you're a continual tinkerer, having your PC on a test bench makes your work easier when you're changing coolant or swapping out hardware. It's good to have the option, either way.

There isn't a lot going on in terms of customisation, at least not when compared with the similarly priced systems we saw in our recent Dream PC Labs. However, there's some very swoonworthy hardware packed in to this compact test bench system.

Aria has opted for Intel's 8-core/16-thread Core i7-5960X, which has been overclocked to 4.5GHz using a vcore of 1.25V; this should enable it to batter pretty much any other CPU into submission. Memory has become much more widely available since our Labs test too, and while most systems in that test used DIMMs clocked around the 2666MHz mark, the Halo Rampage uses 3000MHz Corsair Dominator Platinum, with its 32GB capacity spread across four modules to make the most of the CPU's quad-channel memory controller.

At this price, you'd expect not one, but several graphics cards and the Halo Rampage doesn't disappoint. Three monstrous Nvidia GTX Titan X cards are included, from EVGA's Hydro Copper range, so they're factory water-cooled using EKWB full-cover waterblocks. They're also overclocked out of the box, with the core standing at 1152MHz (1,241MHz boost) compared to the 1000MHz (1075MHz boost) stock frequency. The trio of GPU waterblocks are connected in series and look great, with custom EVGA cut-outs enabling you to see the coolant.

The rest of the water-cooling system is extensive and comprises two massive Thermaltake RL360 triple 120mm-fan radiators, which use six of Thermaltake's new Ring LED fans.

There are two loops too – one deals with the CPU while the other loop cools the trio of graphics cards. Each loop is powered by a Thermaltake P1 pump, which is based around a D5 pump section with a custom Thermaltake top – both pumps are mounted on the base. These pumps are fed by two Thermaltake T22 tube reservoirs, which are mounted horizontally on the top of the test bench and are filled with Thermaltake's 1000 Blue coolant.

The CPU waterblock is – you've guessed it – also made by Thermaltake and is called the W1, although it's definitely a very attractive piece of kit that fits in well with the silver and chrome details on the motherboard. The final piece of the cooling jigsaw is Thermaltake's own branded silver

/SPECIFICATIONS

CPU Intel Core i7-5960X overclocked to 4.5GHz

Motherboard Asus Rampage V Extreme

Memory 32GB 3000MHz Corsair Dominator Platinum DDR4

Graphics 3 x EVGA Hydro Copper Nvidia GeForce GTX Titan X

Storage 400GB Intel SSD 750

Case DimasTech Easy V3

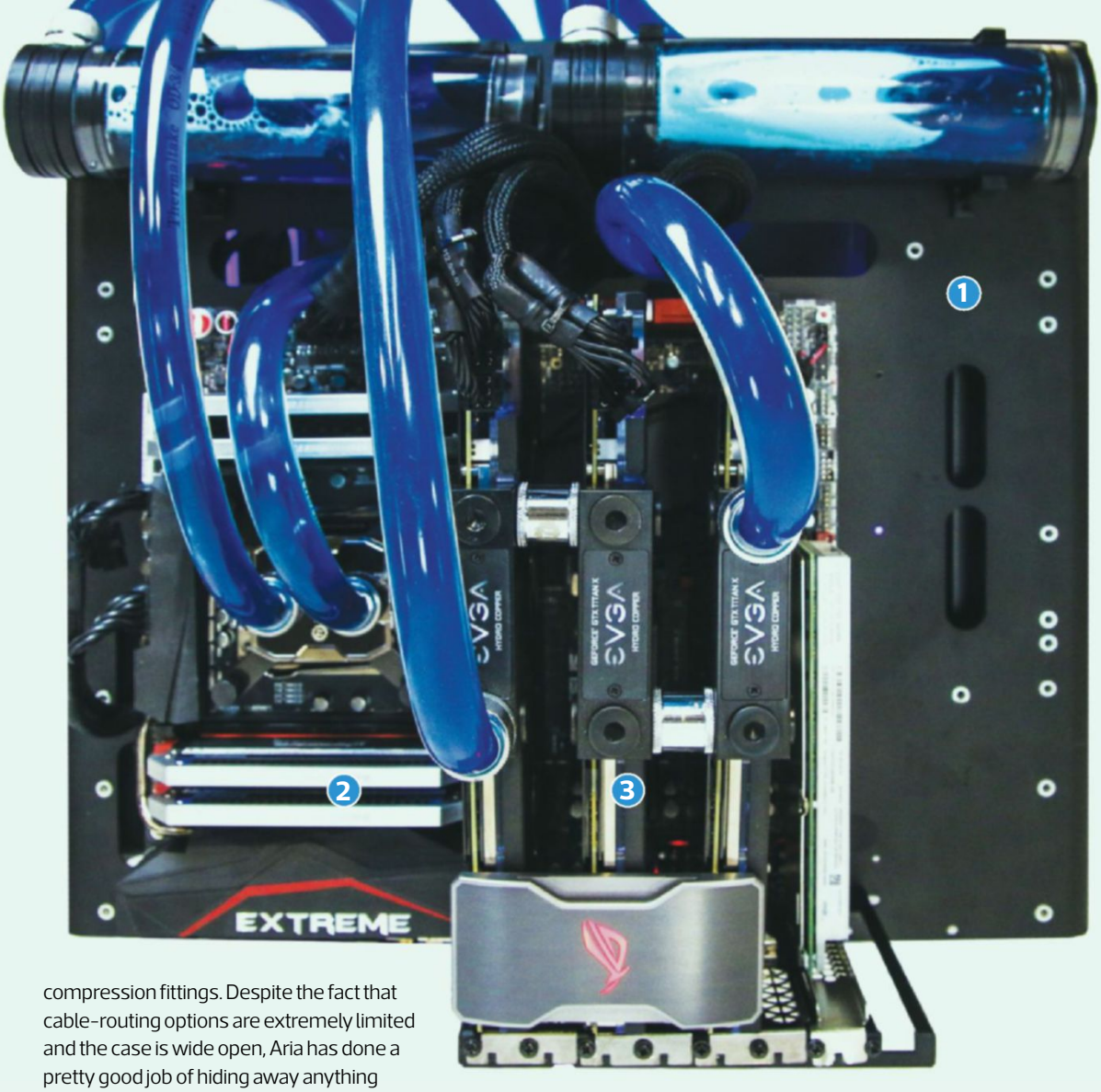
Cooling Thermaltake W1 CPU waterblock, EKWB/EVGA Hydro Copper water-cooled graphics cards, Thermaltake T33 reservoir, Thermaltake P1 pumps, Thermaltake Tubler 4T tubing, Thermaltake RL360 radiators, Thermaltake 1000 Blue coolant, Thermaltake blue Ring 120mm fans

PSU Corsair AX 1200i

Ports Front: none; rear: 10 x USB 3, 2 x USB 2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 6 x audio, PS/2

Operating system Windows 10 64-bit

Warranty One year parts and labour (including two months collect and return), followed by three years labour only return to base



1 All the kit is fitted to a DimasTech Easy V3 test bench, rather than a traditional tower chassis

2 32GB of 3000MHz Corsair Dominator Platinum RAM fills the DDR4 memory slots

3 Three EVGA Titan X cards in SLI configuration ensure amazing gaming performance, but at a cost

compression fittings. Despite the fact that cable-routing options are extremely limited and the case is wide open, Aria has done a pretty good job of hiding away anything unsightly. The illuminated SLI bridge also looks fantastic, although we'd have liked to have seen some custom braided cables at this price.

Storage is top of the range too, with Aria opting for Intel's SSD 750 PCI-E SSD, which comes in 400GB capacity. That's plenty of space for an OS and games, although we'd have liked to see a hard disk or second slower SSD to give you a little more space for other programs and data. Finally, powering the system is a top-end Corsair AX 1200i SPU, and at the heart of it is a Rampage V Extreme motherboard.

Performance

Despite its open air chassis and powerful hardware, the Halo Rampage is very quiet, even under load. In fact, the only indication it's been switched on, in terms of noise, is the slight waft of heat from the side-mounted radiators that draw in air from the front and rear and exhaust it out of the sides.

As expected, the Halo Rampage is really fast too. Let's start with the Intel SSD, which managed blistering read and write speeds in CrystalDiskMark of 2,327MB/sec and 1,035MB/sec respectively – four times as fast as most SATA 6Gbps SSDs, and the read speed is ahead of plenty of M.2 drives we've tested too.

The 4.5GHz CPU and 3000MHz memory did a good job of punching their way through our benchmarks too, with an image editing score of 58,323, a massive video encoding score of 518,355 and a heavy multi-tasking score of 214,154 – all much faster than your average PC, although the higher overclocks of some of the 2015 Dream PCs allowed them to grab a small lead in some tests.

The Halo Rampage's final system score of 209,435 showed this situation clearly – only the 6-core CPU-equipped Scan 3XS Cyclone and moderately overclocked Chillblast Arkham Knight Dream were slower.

Our game tests were then undertaken at 4K and also 2,560 x 1,440. With three GTX Titan X cards at the helm, we didn't expect there to be any issues achieving playable frame rates, and the Halo Rampage delivered in spades. It managed a minimum frame rate of 113fps in the Shadow of Mordor at 4K, rising to 126fps at 2,560 x 1,440. Battlefield 4 was brushed aside too, with a minimum frame rate of 87fps at 4K and a rather ridiculous 161fps at 2,560 x 1,440. Finally, our toughest test was Crysis 3, and 4K fans won't have any issues here, with a minimum frame rate of 89fps and 122fps at 2,560 x 1,440.

These results compare favourably with the Dream PCs – for example, the trio of GTX 980 Ti cards in the Labs-winning

Scan 3XS Barracuda managed a minimum frame rate in Crysis 3 at 4K of 88fps – just 1fps behind the Halo Rampage. The significantly cheaper Scan 3XS X99 Carbon Extreme SLI (see p62) is also hot on its heels, with a Crysis 3 minimum of 83fps.

Battlefield 4 was a tad behind the top-scoring result of OcUK's 8Pack Supernova, though, with its fourth GTX Titan X and monstrous overclock powering ahead to a minimum frame rate 14fps faster at 101fps. We weren't able to get any power consumption numbers due to our testing conditions at the time, but Dino PC's almost identically specced T.Rex drew around 1,100W from the mains, so we'd expect the Halo-Rampage to be similarly power-hungry.

Conclusion

Despite our reservations about using a test bench as the basis for a retail system, the Halo Rampage looks fantastic. The subtle lighting and awesome exposed hardware make it quite different to any of the Dream PCs we saw this year, although if we had £7,500 to spend, we'd still ask Aria to install all the kit in a traditional case for the sake of maintenance, as well as proofing it from dust and drink spills.

The core hardware is generally solid too, although as we found in our graphics card Labs (see p40), the Titan X costs an awful lot of money for a card that's only negligibly quicker than the GTX 980 Ti, and that cost really adds up in three-card setups. In this case, that money could have been better spent on increased storage space and more customisation. We'd usually expect hardline acrylic tubing at this price too, but we agree with Aria that in this case, curved flexible tubing looks better on a test bench.

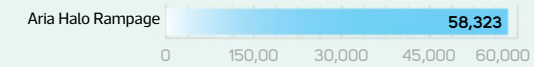
You can't directly compare the Halo Rampage with any other PC we've tested recently, as our two Dream PC price tiers were both significantly above and below its £7,499 price tag. However, the winner at the lower end was Overclockers' Infin8 Emperor, which has similarly good looks, an equally quick CPU, more storage and acrylic tubing – all for £2,100 less. The downside is that it only has two GTX 980 Ti cards compared to the Halo Rampage's three Titan X cards, but then Scan's 3XS Carbon Extreme SLI offers three GTX 980 Ti cards for just £4,799 too.

Nevertheless, it's great to see experimentation in high-end PCs, and the Halo Rampage is a striking machine with great performance. For this money, we'd like to see a better balanced storage system, though, and using GeForce GTX 980 Ti cards would shave a significant amount off the price without hampering gaming performance. The Halo Rampage is a cracking bit of design, though, and we look forward to seeing what else Aria can do in the future.

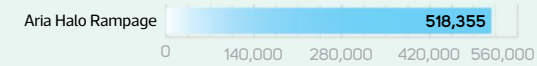
ANTONY LEATHER

CPC REALBENCH 2015

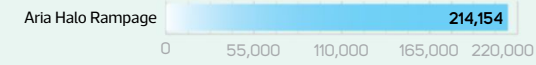
GIMP IMAGE EDITING



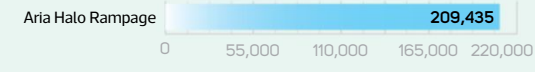
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTITASKING



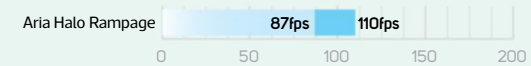
SYSTEM SCORE



INTEL REFERENCE: 182.99%

BATTLEFIELD 4

3,840 x 2,160 Ultra Detail, 0x AA



2,560 x 1,440, Ultra Detail, 4x AA

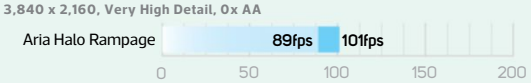
SHADOW OF MORDOR

3,840 x 2,160, Very High Detail, FXAA

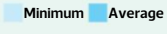
2,560 x 1,440, Ultra Detail, FXAA

CRYSIS 3

3,840 x 2,160, Very High Detail, 0x AA



2,560 x1,440, Very High Detail, 0x AA



SPEED	DESIGN	OVERALL SCORE
24/25	22/25	83%
HARDWARE	**VALUE**	
20/25	17/25	

VERDICT

The Halo Rampage looks great, but it could do with a more balanced storage system, and the Titan X cards needlessly push up the price. We'd also take up Aria's offer to install it in a traditional case.

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Elite

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Build a mini APU PC

The parts you'll need to build an affordable, general-purpose mini PC that's ideal for putting in the lounge, based on an AMD APU. This machine will handle general computing and media tasks with no trouble, as well as basic gaming, although you'll have to lower the detail settings.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	SilverStone Fortress FTZ01	www.scan.co.uk	Issue 144, p84	£100
	Gigabyte F2A88XN-WiFi	www.cclonline.com	Issue 144, p84	£79
	AMD A10-7870K	www.scan.co.uk	Issue 144, p22	£104
	8GB Corsair Vengeance Pro 2400MHz (CMY8GX3M2A2400C11R)	www.scan.co.uk	Issue 144, p84	£41
	Cooler Master Seidon 120V	www.scan.co.uk	Issue 144, p84	£39
	250GB Crucial BX100	www.ebuyer.com	Issue 144, p84	£65
	SilverStone SST-ST30SF	www.scan.co.uk	Issue 144, p84	£41
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£557

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intel inside CHIPSET Z97

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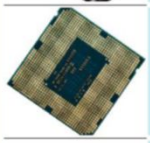
Build a budget gaming PC

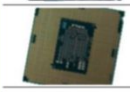
The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor, and even some games at 2,560 x 1,440. The machine has a discrete graphics card, a highly overclockable dual-core CPU and high-speed memory. Meanwhile, the Z97 motherboard gives you headroom to upgrade to a faster CPU later.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	ASRock Z97 Pro3	www.scan.co.uk	Issue 130, p50	£70
	Intel Pentium G3258	www.scan.co.uk	Issue 132, p17	£52
	8GB Corsair Vengeance Pro 2400MHz DDR3 (CMY8GX3M2A2400C11R)	www.scan.co.uk	Issue 132, p22	£41
	AMD Radeon R9 380 2GB UPDATED	www.ebuyer.co.uk	Issue 148, p44	£148
	250GB Crucial BX100	www.ebuyer.com	Issue 144, p84	£65
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£66
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£671

Build a mid-range PC

Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, a 500GB SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Asus Maximus VIII Ranger	www.scan.co.uk	Issue 147, p44	£139
	Intel Core i5-6600K	www.scan.co.uk	Issue 145, p17	£221
	8GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£50
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£75
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£66
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£125
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	**£926**

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 AMD Radeon R9 380 2GB UPDATED	www.ebuyer.co.uk	Issue 148, p44	£148
	2,560 x 1,440 Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 148, p47	£240

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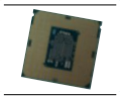
SUPPORTS intel CORE inside

Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory, a high-speed M.2 SSD and an all-in-one liquid cooler.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£137
	Asus Maximus VIII Hero	www.overclockers.co.uk	Issue 146, p20	£170
	Intel Core i7-6700K	www.eclipsecomputers.com	Issue 145, p17	£300
	16GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK16GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£85
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£75
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£95
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Samsung SSD 950 Pro 256GB UPDATED	www.scan.co.uk	Issue 148, p18	£170
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£1,175

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	2,560 x 1,440 Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 148, p47	£240
	4K 2 x Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 140, p50	£480

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UPGRADE TO INTEL 6TH GEN
intel CHIPSET Z170 inside
SUPPORTS intel CORE inside

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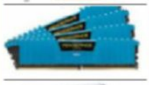
Build a high-end 6-core PC

Multi-threaded PC

The parts you'll need to build a PC with serious power in multi-threaded software, such as 3D rendering apps, video editing programs and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and top-end cooler listed. Also supplied is 16GB of RAM, a super-fast M.2 SSD, 1TB of extra solid state storage and a 1.2kW PSU, providing loads of headroom for adding multiple GPUs.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Asus X99 Deluxe	www.overclockers.co.uk	Issue 136, p20	£315
	Intel Core i7-5820K	www.scan.co.uk	Issue 134, p43	£298
	AMD Radeon R9 380 2GB UPDATED	www.ebuyer.co.uk	Issue 148, p44	£148
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16)	www.scan.co.uk	Issue 136, p14	£96
	EKWB Predator 240i UPDATED	www.scan.co.uk	Issue 148, p30	£170
	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£260
	Samsung SSD 950 Pro 512GB UPDATED	www.scan.co.uk	Issue 148, p18	£320
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£280
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£2,101

4K gaming PC

This LGA2011-v3 system can support multiple graphics cards over 28 PCI-E 3 lanes, making it an ideal foundation for high-resolution PC gaming, replacing the graphics card listed above with two high-spec cards.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	4K 2 x Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 140, p50	£480
			TOTAL	£2,433

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Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a short-PCB graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a high-speed 256GB M.2 SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i7-6700K	www.eclipsecomputers.com	Issue 147, p84	£300
	16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz	www.scan.co.uk	Issue 147, p84	£85
	Corsair H80i GT	www.scan.co.uk	Issue 147, p84	£80
	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£276
	Samsung SSD 950 Pro 256GB	www.scan.co.uk	Issue 148, p18	£170
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£66
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	Asus Z170i Pro Gaming	www.cclonline.com	Issue 147, p26	£125
			TOTAL	£1,329

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	Asus Maximus VIII Gene	www.eclipsecomputers.com	Issue 147, p42	£168
			TOTAL	£1,364

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Budget ATX	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	Sub-£100 ATX quiet	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£80
	Sub-£100 ATX performance	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Sub-£150 full-sized ATX quiet	Nanoxia Deep Silence 5	www.quietpc.com	Issue 144, p50	£113
	Sub-£150 full-sized ATX	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Sub-£150 mid-size ATX	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£137
	Mini-ITX tower	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	Mini-ITX cube	Antec ISK600	www.overclockers.co.uk	Issue 126, p28	£45
	Micro-ATX	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	Water-cooling micro-ATX	Parvum Systems S2.0	www.overclockers.co.uk	Issue 129, p22	£140

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 gaming	AMD Radeon R9 380 2GB UPDATED	www.ebuyer.co.uk	Issue 148, p44	£148
	2,560 x 1,440 gaming	Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 148, p47	£240
	High-end single-GPU gaming	EVGA GeForce GTX 980 Ti Classified ACX 2.0+	www.scan.co.uk	Issue 147, p24	£619
	4K gaming	2 x Nvidia GeForce GTX 970 4GB	www.awd-it.co.uk	Issue 140, p49	£480
	Mini-ITX	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£276

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Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Mid-range 550W	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£66
	High-end 550W	Super Flower Leadex Platinum 550W	www.overclockers.co.uk	Issue 146, p52	£83
	Mid-range 750W	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£95
	High-end 1.2kW	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£266

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Router	Asus RT-AC68U	www.scan.co.uk	Issue 128, p88	£148
	Wi-Fi adaptor	Asus PCE-AC68	www.scan.co.uk	Issue 128, p88	£67

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Hard disk	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	250GB SSD	Crucial BX100 250GB	www.ebuyer.com	Issue 141, p43	£65
	500GB SSD	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£25
	1TB SSD	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£280
	High-performance SSD	Samsung SSD 950 Pro 512GB **UPDATED**	www.scan.co.uk	Issue 148, p18	£320
	NAS box	Synology DS215J	www.cclonline.com	Issue 138, p17	£134

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	24in monitor	Dell U2414H	www.overclockers.co.uk	Issue 129, p43	£186
	29in monitor	Asus PB298Q	www.scan.co.uk	Issue 129, p52	£287
	28in 4K monitor	Asus PB287Q	www.scan.co.uk	Issue 133, p44	£383
	G-Sync monitor	Asus ROG Swift PG278Q	www.eclipsecomputers.com	Issue 143, p44	£552
	FreeSync monitor	BenQ XL2730Z	www.overclockers.co.uk	Issue 143, p46	£456

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Budget mechanical keyboard	Gigabyte Aivia Osmium	www.awd-it.co.uk	Issue 139, p40	£65
	Mechanical gaming keyboard	CM Storm Trigger-Z	www.eclipsecomputers.com	Issue 139, p44	£77
	Mechanical MMO keyboard	Corsair Vengeance K95	www.awd-it.co.uk	Issue 123, p64	£125
	Gaming mouse	Logitech G402 Hyperion Fury	www.currys.co.uk	Issue 139, p53	£40
	Wireless gaming mouse	SteelSeries Sensei Wireless	www.box.co.uk	Issue 139, p61	£100
	Flight stick	Saitek X-55 Rhino H.O.T.A.S.	www.overclockers.co.uk	Issue 131, p29	£170
	Steering wheel and pedals	Thrustmaster TX Ferrari 458 Italia Edition	www.overclockers.co.uk	Issue 137, p32	£300

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G-SYNC™ ROG PG Series
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Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	PCI-E sound card	Asus Strix Raid DLX UPDATED	www.cclonline.com	Issue 148, p28	£137
	USB DAC	Asus Xonar Essence One	www.overclockers.co.uk	Issue 118, p44	£363
	2.1 speakers	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£160
	Soundbar	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£165
	Headset	HyperX Cloud II	www.scan.co.uk	Issue 142, p46	£68
	Surround-sound headset	Asus Strix 7.1	www.cclonline.com	Issue 142, p43	£130

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Quiet gaming PC	Chillblast Fusion Serenity	www.chillblast.co.uk	Issue 138, p66	c. £1,499
	Dream PC	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	Sub-£2,000 gaming PC	Scan 3XS X99 Carbon Ti	www.scan.co.uk	Issue 143, p58	c.£1,999
	Skylake PC	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 145, p66	c. £1,449
	Mini-ITX gaming PC	Chillblast Fusion Fury Nano	www.chillblast.co.uk	Issue 147, p56	£1,619
	Gaming laptop	MSI GT70 2PC Dominator	www.overclockers.co.uk	Issue 129, p26	c. £1,320
	Premium PC	Scan 3XS X99 Carbon Extreme SLI UPDATED	www.scan.co.uk	Issue 148, p62	c.£4,799

Games

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RICK LANE / INVERSE LOOK

BUBBLE TROUBLE

Rick Lane pops the 'indie bubble' and the notion that Steam has too many games

The game industry is currently in rude health, with more titles being released than ever before. In 2013, 561 games were released on Steam alone, and that number skyrocketed to 1,814 last year. And that's just Steam, never mind the dozens, perhaps hundreds of games exclusive to console platforms, alongside the thousands of mobile games that populate the Apple and Android online stores.

This growth is viewed as a cause for concern in some corners of the industry, particularly with regard to Steam's proliferation. Indie developers such as Jeff Vogel have claimed that the so-called 'indie bubble' is about to burst in a similar way to the 1983 video game market crash. Such worries aren't entirely unjustified. Valve doesn't regulate the quality of games launched on Steam, which means many of them, especially Early Access games, are released in a poor state.

The theory goes that this abundance of half-finished survival games and cynical Early Access cash-ins obscures the presence of genuinely excellent games released alongside them, resulting in lost sales and, in the worst-case scenario, the closure of small developers.

However, while Steam might offer a large number of games – a reasonable number of which are rubbish – the audience for those games is massive. In February this year, the number of active Steam users clocked in at 125 million, with almost 9 million people using the service at any one time. Even if we assume that one user only buys and plays one game on the service, that's 25,000 players for each of Steam's (approximate) total of 5,000 titles. Of course, this statistical simplification bears little relation to people's actual buying habits. Most active Steam users will own multiple games, and popular titles such as Dota 2, Counter-Strike and Call of Duty have massive audiences, while others only sell a few hundred copies.

> In February this year, the number of active Steam users clocked in at 125 million

Nevertheless, it's clear that the demand for games on Steam massively exceeds the supply. Compare those figures with another major media industry – books. Last year in the UK alone, approximately 184,000 books were published. If every person in the UK (approximately 70 million people) purchased one book, that equates to just 380 readers per book. Even if we factor in the populations of other English-speaking countries such as the USA, Canada, and Australia (approximately 319 million, 35 million and 23 million), you still only come out with 2,429 readers just for UK books.

The fact that some games fail to attract an audience doesn't signal a forthcoming apocalyptic market crash. Even if large numbers of games were stalling in sales, it would be wrong to equate the crash of 1983 – where games were played on specific consoles that had to be manufactured and sold at a profit – to Steam, which acts as a marketplace and is semi-autonomous of Valve, a company that still develops games and hardware as a source of income. Theoretically, Steam's demise would leave a massive hole in the market, but there are already plenty of alternatives to Steam for PC gaming.

The game industry may have more competing developers than ever before, but the audience is also larger than ever before. Services such as Steam make it far easier for the two to meet. There's no need to make a royalties deal with a big publisher, pay for manufacturing of boxes or discs, or negotiate for shelf space with a retailer. None of these benefits guarantees a developer success, of course, but it doesn't guarantee failure either. CPC

Rick Lane is Custom PC's games editor. @Rick_Lane

Prison Architect / £23 inc VAT

DEVELOPER Introversion / **PUBLISHER** Introversion / **WEBSITE** www.introversion.co.uk/prisonarchitect

Prison Architect isn't only significant because of the final product's quality, but also because of the nature of its development. It was one of the first games to adopt an 'Alpha' development model, before the creation of Steam Early Access. Over the past three years, it's proved itself a stalwart example of this design process, receiving constant updates that have carefully expanded upon its basic premise of constructing and managing a maximum security prison. Now, finally, Introversion has officially updated Prison Architect to the hallowed version 1.0, and the result is one of the most distinctive and fascinating management sims since Theme Hospital.

That said, it isn't quite as accessible as Bullfrog's classic. Indeed, Prison Architect begins with a bamboozling lack of ceremony. Select New Prison mode and you're dropped straight into a plot of virgin land with a criminally small budget and a meagre serving of instructions. Select Career mode, on the other hand, and you arrive in a comprehensive five-mission tutorial, which confusingly begins with the construction of an execution chamber so that your prison can carry out a death sentence.

Like Andy Dufresne's arrival at Shawshank Penitentiary, Prison Architect doesn't offer the warmest of introductions, but once you get your head around the career mode's counter-intuitive opening, it all starts to make sense. The Career mode guides you through laying building foundations, designating room types, catering to your prisoner's needs, dealing with riots and managing its web of bureaucracy. It also tells some surprisingly compelling tales of prison life, from the tragic execution of a repentant murderer to a misguided civil war within a mafia family.

Ultimately, though, the Career mode is little more than an overnight stay in the drunk tank. Your sentence truly begins when you construct a prison of your own, expanding from a simple holding cell with an attached canteen to a complex network of cell blocks, showers, exercise yards, managing offices, communal spaces, visitation rooms, workshops and half a dozen other facilities.

Underpinning the game is a core system in which every action you designate has to be carried out by a member of your prison's staff, so any foundations you plot out have to be constructed manually by a team of workmen. Objects from prison doors to toilets need to be transported from storage and installed, while water pipes and electricity cables must also be laid out by hand. Cell doors must be opened by guards, meals cooked and served by chefs, and rooms cleaned by janitors. Even your prison psychologist has to attend therapy sessions in person.

As such, the construction of your prison takes time, and the delay between action and resolution means some mental gymnastics are required to keep your prison running. Money, for example, is extremely tight, but you can acquire large chunks of funding through grants, which fund your prison for meeting certain requirements such as ensuring your prisoners receive sufficient family time. Many of these grants pay advances, so a common trick is to accept a new grant and use the advance to complete a previous grant project, and then use the funds paid for completing the old grant project to start a new one.

Alongside finance is the issue of looking after your inmates. All your prisoners have a list of needs, ranging from food and hygiene to vaguer requirements such as safety and company. These needs intensify the longer they go unfulfilled. For every day you put off the construction of the new shower block, you get several dozen prisoners becoming increasingly irritated by the smell of their armpits. Eventually, such neglect will lead to fights, murders and full-blown riots.

Playing Prison Architect is an exercise in plate spinning, and it's only a matter of time before one crashes to the ground. It might be that you forgot to add enough capacitors to your power generator, resulting in a blackout that triggers multiple escape attempts. Or perhaps you might have neglected to search the prisoners' cells, causing a spate of drug addictions, opportunistic shankings or the digging of escape tunnels. Even doing what's expected, such as giving regular shakedowns, can cause unrest to increase, sparking off further problems down the line.

The attention to detail in Prison Architect's systems is remarkable. Every action feeds into the simulation and spits out a noticeable result at the other end. There are a couple of issues, however. The level of interconnection means even a small bug can potentially spike your entire prison. In our game, a door became stuck shut for no apparent reason, sealing off an entire wing of the prison from all the basic amenities for several days. Fortunately, the wing was newly built and there were no prisoners residing in it, otherwise it would definitely have caused a riot.

OVERALL SCORE
85%

/ VERDICT
Original, richly complex and surprisingly emotive, Prison Architect is a splendid management sim, provided you survive your first night within its walls.

Also, while Prison Architect is great at producing emergent stories, they don't tend to be stories about individual prisoners, despite the fact that each prisoner has an extensive background and a list of traits attached to them. That's partly because unfulfilled needs tend to affect your prisoners en masse, and partly because there's so much going on at any given moment that individual prisoners tend to be neglected, a curiously fitting indictment of mass incarceration that we doubt is entirely accidental.

Indeed, what's perhaps most impressive about Prison Architect is how it uses its theme to create a fun and engaging game without diminishing or exploiting its dark subject matter. The art style might sport a light-hearted, cartoony vibe, but when 20 of those prisoners are slamming themselves against a prison door, screaming about their crippling drug withdrawal, the aesthetic qualities have the all the softening effect of a boxing glove on a fist.

Prison Architect isn't preachy, and carries no message per se, but it never shies away from the darkest aspects of prison life. You can treat your prisoners like human beings, rehabilitating them as they serve their sentences. Alternatively, you can exploit them for capital gain, sending them to toil endlessly in workshops, or squeezing them into tiny cells to rake in more money from the state.

Any game that communicates a meaning and sense of purpose entirely through its systems is always worth investigating, and Prison Architect is absolutely one of those games. It may not be the friendliest management sim around, but it's richly complex, unique and fascinating.

RICK LANE

Life is Strange / £16 inc VAT

DEVELOPER Dontnod Entertainment/ **PUBLISHER** Square Enix/ **WEBSITE** www.lifeisstrange.com

OVERALL SCORE
82%

/ VERDICT
Clumsy climax aside, Life is Strange offers a dark, warm, human tale of the consequences of growing up.

Life is Strange is a gripping interactive drama about teenagers, time travel and tornados. It's played from the perspective of student photographer Maxine Caulfield. During a class, Max has a premonition that her hometown of Arcadia Bay will be destroyed by a tornado. Then, when she regains consciousness, she finds she has the ability to reverse time.

Max uses this ability to manipulate events around her, starting by saving the life of her childhood friend Chloe Price, who is investigating the disappearance of another student, Rachel Amber.

To put it crudely, the game combines the structure of Telltale's The Walking Dead Series with a distinctly Twin Peaks-esque suburban gothic theme, blending soap opera drama with gritty amateur sleuthing and supernatural elements. Interaction is limited to environment exploration and puzzle solving of varying complexity, and emphasis is placed on dialogue, character relationships and decision making.

Initially, Max's concerns involve simply fitting in at her local college, and trying to re-establish her friendship with Chloe, which has cooled in the wake of Chloe's father's

SOMA / £23 inc VAT

DEVELOPER Frictional Games/ **PUBLISHER** Frictional Games/ **WEBSITE** www.somagame.com

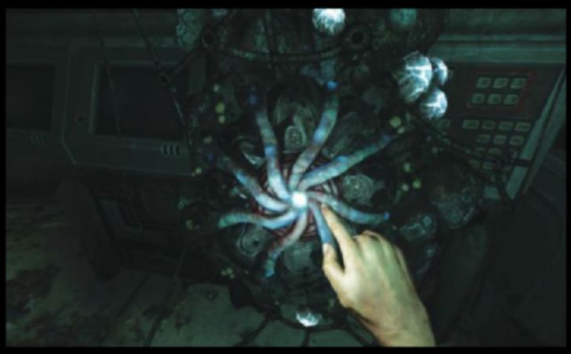
OVERALL SCORE
82%

/ VERDICT
Frictional's attempt to move towards more complex scares meets with mixed success, but the experience remains compelling.

Frictional Games is a master of virtual horror. The developer's Penumbra series was a chilling and original debut, while its most notable work, Amnesia: The Dark Descent, redefined the genre to the extent that its framework has been copied by dozens of developers since. SOMA represents an attempt to move away from the conventions established by Amnesia, though, offering a horror game that's more philosophical and introspective, and less about being chased down corridors by monsters.

The game takes place roughly a century in the future, when the underwater research base of Pathos II witnesses a sequence of slow-burning disasters that gradually coil around the compound. Your character, Simon Jarrett, awakes in Pathos II with no knowledge of how he arrived. To discover what happened, he must travel between the base's multiple facilities, avoiding strange creatures and picking apart the mystery.

To be any more specific would reveal too much of the plot, which is smartly conceived and brilliantly told, with snappy and witty writing and voice acting, plus startlingly human characters. For much of the game, SOMA partners you with another Pathos II researcher



called Katherine, and much of the horror relies on cleverly building your relationship with her before abruptly pulling you away, emphasising your isolation and vulnerability.

But the horror goes deeper than simple loneliness. Pathos II is a battleground between nature and technology. The gleaming gunmetal corridors of its stations groan and squeal beneath thousands of tonnes of water, while the exteriors of its facilities are caked in coral and aquatic flora. This theme extends to the story too. In Pathos II, the line between machine and organism is blurred, and it's often up to you to decide where the line is drawn. In one example,

death and Max moving away. Indeed, much of the enjoyment comes from the quieter moments in Max and Chloe's friendship, watching them chat excitedly in a diner, holding hands as they walk down a woodland rail track and dancing in Chloe's attic bedroom. It's often a tender, touching game, exploring themes of growing up as the pair face the trials of adulthood together.

But these moments of warmth are interspersed in a speedily paced plot that carefully deals with tricky subjects such as murder, suicide, abduction, date rape and slut shaming. You aren't a passive observer either. At certain points, Life is Strange forces you to make difficult choices, such as whether you should tell the authorities about an attempted murder, and potentially get a friend into trouble, or instead keep it a secret and risk a repeat incident further down the line. Interestingly, you can use Max's time reversal ability to explore all the available avenues. Cleverly, however, while you'll see some of the consequences of your actions, the overall effects of your decision only become apparent much later.

The game isn't without its flaws though. Aesthetically, it's quaintly beautiful, but the animations are rather puppet-like and facial expressions are poor. Also, while the script is generally sharp and entertaining, DontNod's effort at teenage jargon is excruciating. Lastly, while the episodes generally increase in quality as the series goes on, the final episode is a noticeable step backwards. The game struggles to unify all the reality-skipping plot threads, and it feels like there's a lot of filler material, including an extended dream sequence that's simply boring.

Fortunately, it's worth persevering for the ending itself and, despite the terrible events that happen in the story, Life is Strange offers a warm and human tale about growing up.

RICK LANE

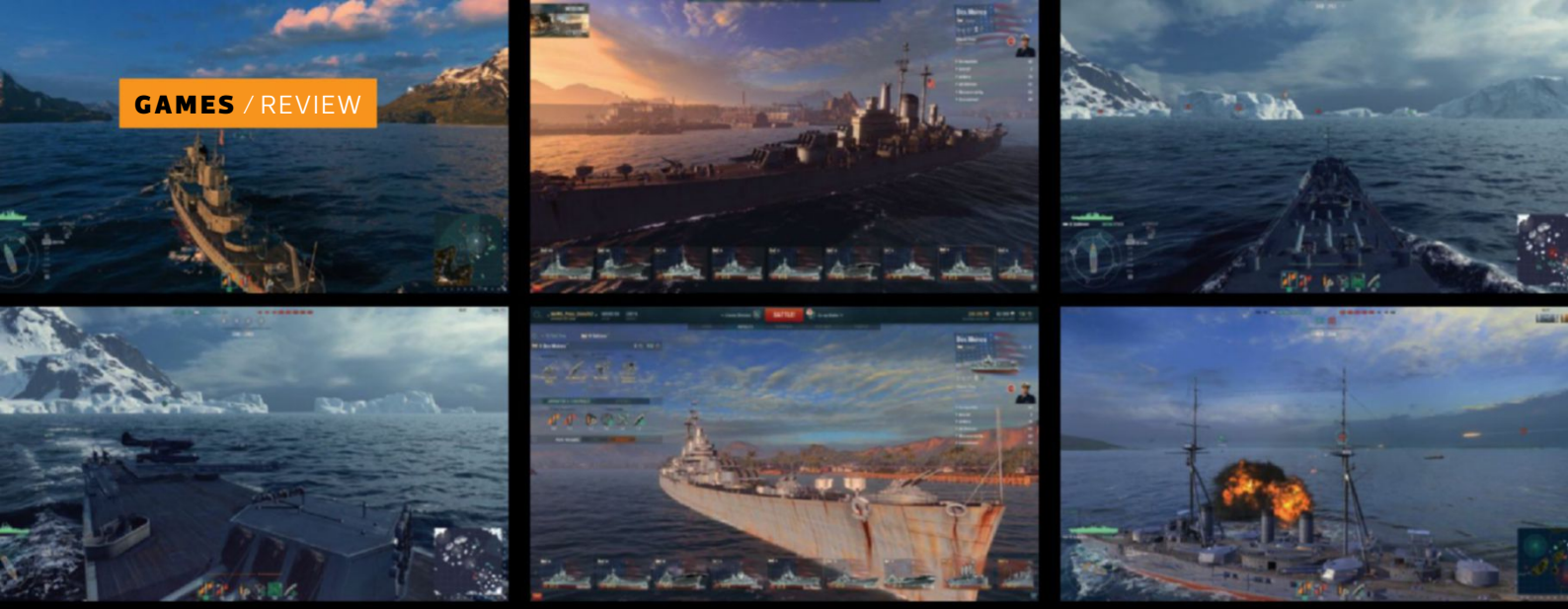
you encounter a damaged robot that insists it's human. The robot's situation also obscures your progress, and you have to decide whether to use an easy solution, which will kill it, or a difficult solution, which will keep it alive.

SOMA is at its best when posing philosophical quandaries or engaging you through its simple but wonderfully tactile puzzles; however, elsewhere it struggles a little. The sequences during which you need to evade monsters feel distinctly undercooked. The monsters' patrols are fairly predictable and your options for dealing with them are limited to cowering in a corner until they go away.

There are also no core systems that underpin the game, as with Amnesia and its sanity system. Rather, it's a collection of smaller ideas that have been carefully threaded together.

It works for the most part, but there are periods when SOMA feels interactively barren, particularly when travelling between stations, where the murky underwater environments offer little to see or do. In the end, though, SOMA's tale shines through in a generally well-crafted horror game that offers more than simple scares.

RICK LANE



World of Warships / FREE TO PLAY

DEVELOPER Wargaming St Petersburg / **PUBLISHER** Wargaming.net

World of Warships is the third and final entry in Wargaming's series of multiplayer vehicular shooters, after the brilliant World of Tanks and the mediocre World of Warplanes. In terms of quality, Warships falls between the two. It's more enjoyable than Warplanes, but lacks some of the spark that made Tanks a stratospheric hit.

Like its brothers, Warships' setup is simple. When the game launches, you select a ship and click the big orange Battle button and you're then dropped into a form of team-deathmatch with 13 other players. There are several game modes that revolve around capturing aquatic territory in a series of island archipelagos, but most of the time, the experience is one of straightforward naval combat; the team that wins is the one that sinks all the enemy ships.

As a deathmatch game, Warships is novel, intriguing and occasionally exhilarating. It plays much slower than other shooters due to the massive vehicles, so a volley of artillery shells takes several seconds to hit their target, and even basic movements such as accelerating and turning are deliberately ponderous.

This pace has two effects. Firstly, it conveys the size and bulk of the vessels brilliantly. Secondly, it adds an interesting tactical layer, as you need to think several seconds ahead of the action that's playing out on screen. If you see artillery shells coming your way, there's little you can do but bear the brunt of the impact. Instead, your thoughts should be on avoiding the *next* volley. Likewise, when aiming your own guns, you need to set your sights where your target will be situated when your shells land, rather than their present position.

The number of ships available to sail is impressive, and each handles in a noticeably different way. Speed, manoeuvrability and damage output all vary ship to ship, as do abilities such as radar, torpedoes and on-board air support. One class of ship, the aircraft carrier, has a totally different control method, played from a top-down, RTS-like perspective, although its indirect approach to combat makes it the least entertaining class to play.

However, the short and simple nature of each match makes the game become repetitive fairly quickly, and unlocking the best ships requires either a hefty donation from your wallet or hours of grind. As with Warplanes, Warships could have done with less emphasis on the number of ships, and more thought put into the variety of play. There are also times when the game's slow nature makes it become monotonous, especially towards the conclusion of matches when only one enemy ship remains and everyone is trying to chase it down.

Still, there's fun to be had with World of Warships, and it's particularly well suited to short bouts of play. Experimenting costs nothing, so if you fancy a slightly different multiplayer experience, it's worth climbing aboard.

RICK LANE

OVERALL SCORE
70%

/ VERDICT
World of Warships' slower, more tactical shootouts make it one of the more interesting shooters, although it can be too slow for its own good.

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RICK LANE / THE ENGINE ROOM

Frictional HPL 3

After the brilliantly scary Amnesia, Frictional games added HDR lighting, terrain and a new shading language to HPL for SOMA. Rick Lane investigates

When we last braved the dark and spooky code of Frictional Games' HPL Engine in 2012, the Swedish developer was in the middle of upgrading its homebrew tech, in anticipation of its next project, SOMA (see p82). Fast forward another 2.5 years, and SOMA has finally been released, supported by HPL version 3 in all its gloomy glory. But what terrifying surprises await beneath the surface of Frictional's latest tech, and why has it taken five years for the game to finally emerge?

'Basically, it's been very hard to figure out how to approach the game, and there has also been a bit of a tech build-up,' says Thomas Grip, co-founder of Frictional games and lead developer on SOMA. 'We've added terrain and HDR lighting, which I think are the big additions. It doesn't sound like much, but those features extend into tonnes of stuff.' In fact, Grip sells HPL 3 a little short. Alongside terrain and HDR lighting, HPL 3 also includes global sunlight and shadowing, alongside a new High Level Shading Language known in-house as HPSL.

Many of these changes were consequences of SOMA's setting – an underwater research facility named Pathos II. Frictional was attracted to the underwater setting because of humanity's relatively limited knowledge about the deep ocean, making it a fitting locale for both science fiction and horror stories. 'It's an interesting sci-fi environment, and I think it's also interesting because it's very close to us,' Grip explains. 'It's almost like having Lovecraft stories where you have this alternate dimension just around the corner – the ocean is a little like that in terms of how much we know about it – it's very unexplored.'

Frictional's previous game, Amnesia, was based on HPL 2

HPL 3 can support much larger terrain than that shown in the final version of SOMA

Rather ironically, the decision to create an underwater game meant that HPL would have to support terrain. Pathos II is situated on the ocean floor, and comprises a cluster of separate research stations. At various points in the game, the player has to travel between them by navigating the ocean floor.

There are lots of ways to create virtual terrain, and the generation technique Frictional uses is called geomipmapping. To briefly summarise, geomipmapping works by generating a 2D heightmap using a gradient noise algorithm (see our procedural generation feature over the page for more information) before rendering the 3D geometry entirely on the GPU. Importantly, geomipmapping has a built-in ratio of the vertices used against the distance to the camera. As such, the further away a piece of geometry sits from the game camera, the fewer vertices are used to render it, allowing for vast, rolling vistas that phase in detail as the player gets closer.

Geomipmapping proved very effective for implementing SOMA's terrain. Too effective, in fact. 'We could support several square kilometres of terrain, but that turned out to be a bad move,' says Grip. 'I know we had one map where we just

made it smaller and smaller ten times over, and it made more sense there – it's annoying using this technology for huge areas, but we're using it mainly for small ones.'

Part of the problem is that, although the ocean floor is obviously massive, you can't actually see that far in front of you, so early play testers exploring these massive areas would simply get lost. 'If you look at other terrain games, you have long visibility, so if you're going to a building in the distance, you can still see it if you're far away,' says Grip. 'But that's not possible for us because there's nothing to see 20m away, and that's what we want – it gives you that authentic, oppressive underwater feeling.'

As parts of SOMA take place outdoors, Frictional had to make changes to its lighting model as well. The team wanted to simulate how sunlight refracts and scatters onto other objects, which involved several steps. Firstly, the team implemented a hemispherical lighting technique, where sky and ground colours are separated and then blended together, which emphasises the contrast between the two and makes them easier to differentiate. Next, it tweaked the existing shaders of HPL 2 in order to simulate the direct light of the sun, a simple enough technique that involves lighting every pixel from the same direction. Lastly, the team added cascaded shadow maps, enabling shadows on objects to be rendered at a distance without a hefty performance impact.

As we mentioned earlier, HPL 3 also introduces HDR lighting to Frictional's games. HDR provides a much greater range of luminescence from light sources. HDR is important in a horror game such as SOMA, where you want the transitions from darkness to light to be striking and have an impact on the player. When you enter a deactivated facility station and switch on the fluorescent lights, you want to feel that oppressive atmosphere lessen a little, and vice versa.

The last major addition to HPL3 is the HPSL shading language, introduced mainly so that the engine could support both PCs and the latest consoles. 'Targeting PS4 has involved a lot of technical challenges because its CPU performance is built on multithreading,' says Grip.

Environments are much busier in SOMA than in previous Frictional games, with a real 'lived-in' feel

HPL supports full HDR lighting and global illumination

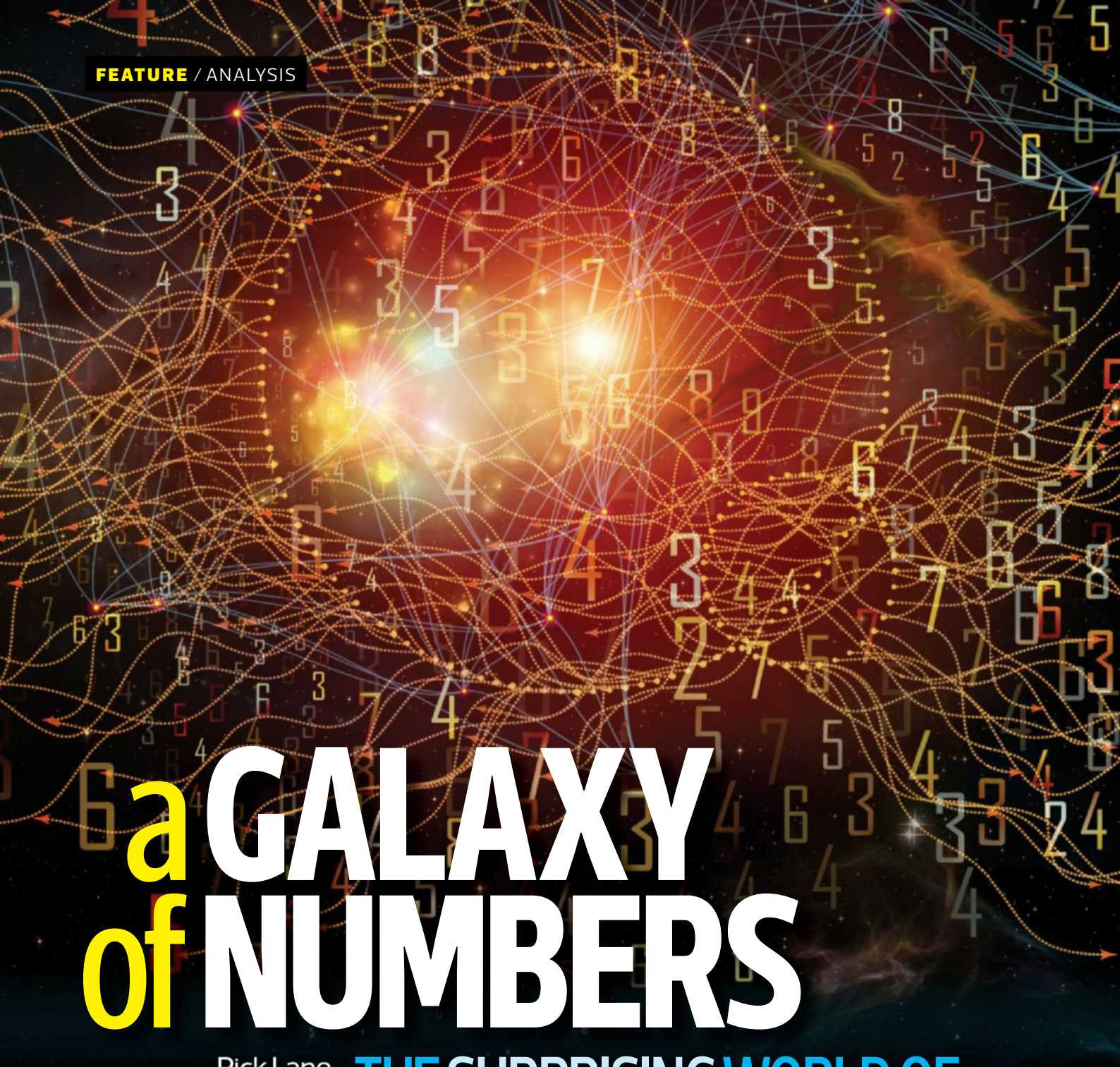
'The CPU is pretty weak if you use just a single core, but it comes into its own when you start using multithreading. Our engine isn't made for multithreading, so we had to spend a lot of time on it.'

Away from the more fundamental changes to the engine, Frictional has altered the emphasis of some of HPL's existing features for SOMA. The most notable difference concerns the manual physics system. Every object in the game world, from doors to light switches, is operated by clicking and dragging the mouse, engendering a powerful sense of tactility in the environments. With SOMA, the physical focus is less on large, complex puzzles, and more on smaller, detailed interactions.

The fun physics manipulation of earlier HPL games remains, but in smaller, more detailed interactions

'What I think is different from Penumbra to Amnesia is that the physics interaction has gone from huge stuff – you can operate a crane in Penumbra – to smaller stuff; in Amnesia, you can pick up and throw a bottle and it crashes,' Grip explains. 'We've taken the same step in SOMA, where there are more small interactions you can perform, such as pulling drapes open.'

The end result is a game that looks and feels strikingly different from Frictional's previous effort, Amnesia. The improved lighting helps imbue the environments with greater variety, and it's surprising what a difference the ability to go outside makes, even if the outside happens to be filled with water. **CPC**



a GALAXY of NUMBERS

THE SURPRISING WORLD OF PROCEDURAL GENERATION

Rick Lane investigates how procedurally generated games are becoming larger, more complex and more meaningful than ever before

Dan Marshall's game wasn't working. In late 2013, two years into development, the head of indie studio Size Five Games officially put The Swindle on hold. This side-scrolling crime caper, in which you break into buildings ranging from rundown squats to high-security banks, simply wasn't proving to be the thrilling burglary simulator Marshall had intended.

'Originally, you'd keep going back to the same buildings, but the AI would add security to your previous route, so if you went through the sewers beforehand, the AI would block it off and add cameras or more guard patrols,' Marshall says. 'It was one of those ideas that looked great on paper, but just didn't work in practice. You'd never retry that route; you'd always be looking for a different, new route in. The whole thing just didn't gel together in a coherent way, so I ditched it.'

Nothing was heard about The Swindle for another year. Then, at the end of 2014, it re-emerged with a bold new art style and, more importantly, a completely reworked play structure where every mission saw the player breaking into a new building with a procedurally generated layout. The handful of building types Marshall had

initially planned became templates for an unlimited number of potential structures, each one a fresh challenge for the player. It no longer mattered that players would always opt for a new route, because the target itself was new as well.

Even with the earliest prototypes of this reworked version, Marshall knew he was onto something. This version didn't have full graphics, just 'rectangles running around black and white buildings hitting rectangles with other rectangles,' says Marshall. 'I was booting it up to test a bug and losing hours to just playing it. It was immediately interesting to play.' Marshall's belief proved sound when The Swindle was released in July this year, and was warmly received by critics and players alike.

That Marshall solved the problem at the heart of The Swindle using procedural generation isn't entirely surprising, simply because procedural generation is one of the game industry's greatest problem solvers. Over several decades, procedural generation has been used to solve a broad range of problems in games, such as making a game surprising every time it's played, creating realistic landscapes without working all your 3D artists to death and rendering an entire galaxy using just 32KB of memory. It's a technique that can be applied to almost any aspect of video game creation, from art to AI.

Procedural generation embodies the essence of game development – using a set of rules to create unique experiences for the player. Yet despite the ubiquitous and essential nature of its random seeds and algorithms, procedural generation seems arcane and mysterious from the player's perspective. How does it work, where does it come into effect, what are its limitations and where can it take gaming in the future?

The Swindle's buildings bear no resemblance to logical architecture, and it can even prove impossible to escape from them if you're not careful

The pseudorandom number generator

Guinness World Records gives the award for first use of procedural generation to Elite for its procedurally generated galaxy. However, there are earlier examples, such as the landmark 1980 dungeon crawler Rogue, where the placement of all chambers of the dungeon and the objects within them were generated randomly. Yet Rogue was itself predated by Beneath Apple Manor, a similarly styled game created by Don Worth in 1978.

Regardless of who arrived there first, all procedural generation relies on the same fundamental principle – pseudorandom number generation. In brief, a pseudorandom number generator outputs a number or sequence of numbers from an arbitrary initial set of values called a seed or seed state. Such number generators aren't actually random, as the seed determines directly the number sequence that is outputted. From the user's perspective, though, it appears that the computer is pulling a random number from the air.

Pseudorandom number generators are the basic ingredient of procedural generation, but that generation only truly begins when you commit those random number generators to a more specific task, which is achieved using a procedural algorithm. With 1980's Rogue, the algorithm generated a 2D, top-down map of rectangular rooms and connecting corridors rendered in ASCII graphics. This method has since become known as a dungeon generation algorithm, and variations upon it are still used today. Indeed, The Swindle's approach to its procedurally generated building layouts closely resembles the process of those early dungeon generators.

The Swindle's procedural algorithms reflect the early dungeon generators of games such as Rogue

'The building starts as a blocked-out tile map of varying sizes, and the procedural generator digs out a load of randomly sized rooms throughout it,' Marshall explains. 'Those rooms are connected with corridors, and we add corridors from the left/rightmost rooms to the outside (so there's always an entrance/exit), and then the ground level stuff is added. We then "eat away" across the top of the building down to the rooms, and that forms the basis of our roof.'

It's important to note that procedural generation isn't the same as random

generation. The entire point of a procedural algorithm is to sculpt those pseudorandom numbers towards a specific goal. It's essentially commencing the construction of a game from what logically seems to be the wrong end. Instead of starting with a blank canvas and filling it in, you're essentially beginning with *every possible number in the universe* and narrowing down your vision from that point. 'In reality, it's a bit of a faff because you're constantly tweaking numbers, or breaking things by adding new features, says Marshall.

'Even at the last minute, you'll generate your 100,000th level during testing and will do something stupid you've never seen before.'

Minecraft's cube-constructed mountains and valleys emerge from the positive and negative dot-products of the Perlin Noise algorithm

Generating terrain

While procedural generation got its start in random dungeons, the technique is now most commonly used for terrain generation – creating realistic landscapes with hills, valleys, mountains, riverbeds and so on. Generating 3D terrain requires more complex algorithms, the most fundamental of which is arguably the midpoint-displacement algorithm. This algorithm works by taking a rectangle and assigning a height value to each of its corners, before dividing the rectangle into four smaller rectangles. The heights of the corners of the new rectangles are then assigned the mean value between the corners of the larger rectangle. This process is repeated over and over until you end up with a rugged surface of contours.

Midpoint displacement is a form of fractal subdivision. One of the earliest games to use the technique was 1985's Rescue on Fractalus, in which you fly a spaceship over a rugged planet and rescue downed pilots trapped on its terrain. Various advancements in fractal subdivision have been made over traditional midpoint-displacement, such as the diamond-square algorithm, which uses a square in the place of a rectangle and adds an extra height value to a node in the centre. This algorithm splits the square into four 'diamond' shaped triangles, at which point the square is divided into four smaller squares.

IT'S FUN TO THINK THAT, IN THE BACKGROUND, IT RUNS THIS WHOLE BIOLOGICAL SIMULATION OF THE ISLAND TOO

But there are other types of procedural generation algorithms that have nothing to do with fractals. One of the most powerful algorithms is named Perlin Noise. It was created in 1983 by computer scientist Ken Perlin, and was so influential in 3D graphics that in 1997 Perlin was given an Academy Award for his technical achievement.

Describing exactly how Perlin Noise works would require an article itself. However, in very basic terms, it functions by calculating two types of pseudorandom vectors (known as the gradient vector and the distance vector) from the four corners of a square (or the eight corners of a cube if you're working with 3D terrain), then returning a single value known as a dot product from between those two vectors.

If the two vectors are facing in the same direction, the dot product has a positive value; if they're facing in the opposite direction, the dot product has a negative value. In visual terms, these positive and negative values might be represented as dark and light areas on a 2D texture, or bumps and troughs on a 3D map.

What makes Perlin Noise so significant is its range of possible uses. It can be used to create 2D and 3D terrain, and can even be used to create animated textures such as fire effects. Perhaps the most well-known game to use Perlin Noise today is Minecraft. Its cube-constructed mountains and valleys emerge from the positive and negative dot-products of Perlin Noise.

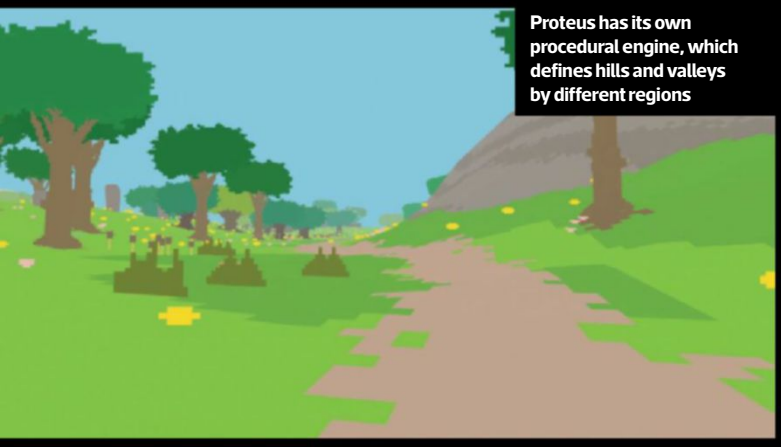
While these algorithms are important milestones for procedural generation, each game that uses the technique has different requirements from it, and each developer will tweak and iterate upon the algorithms in different ways. For his first project, the musical exploration game Proteus, developer Ed Key experimented with various procedural generation algorithms, including Diamond Square and Perlin Noise, before constructing a procedural engine of his own.

'Proteus has this way of laying out regions and painting some of them as mountain ranges and some as valleys. In the centre of each of these blobby regions it connects together, there's a load of landmark features it can put down,' says Key. 'Once this landscape has been roughly created, there are rules about where these features want to go and what sort of area they want to sit in – they all kind of compete.'

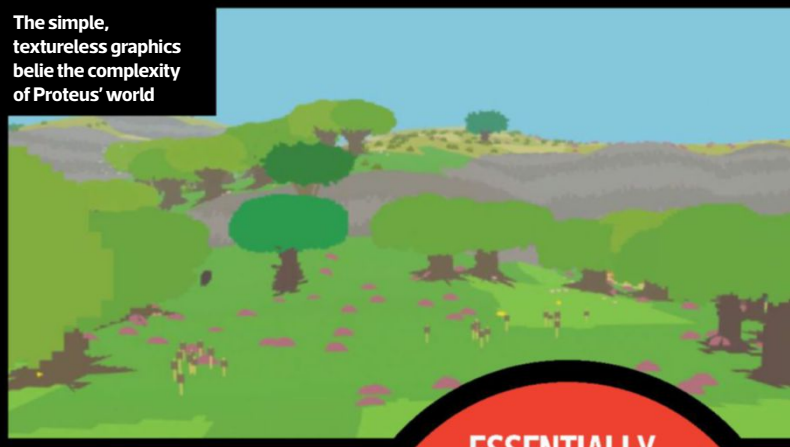
In Proteus, this notion of competition expands beyond the game's manmade landmarks. Before a game of Proteus even starts, the flora and fauna of its world are simulated over several, board game-like turns. 'It has this abstract, simplified biological process where they spread and compete with each other and push each other around a bit,'

Before the game starts, Proteus runs a simple biological simulation that determines plant placement

Major landmarks, such as this large tree, compete for a place on Proteus' island



Proteus has its own procedural engine, which defines hills and valleys by different regions



The simple, textureless graphics belie the complexity of Proteus' world

Key explains. 'It makes nice distributions; it's fun to think that, in the background, it runs this whole (very simple) biological simulation of the island too.'

Generating a galaxy

The notion of evolution and competition is where procedural generation becomes especially interesting. Rather than inputting a bunch of pseudorandom numbers into an algorithm and accepting whatever it outputs immediately, it's possible to take that basic height map and then simulate a variety of natural processes on it, resulting in a more natural-looking landscape. In the extreme, it's even possible to create an entire galaxy this way, as Frontier Developments did when it returned to its landmark procedurally generated space sim in the form of Elite: Dangerous.

'Procedural generation often has connotations with random generation, like a dice roll. For Elite Dangerous, the generation of content works from first principles,' says Michael Brooks, executive producer on Elite Dangerous. 'For example, when creating the contents of a star system, we actually simulate every aspect of its formation from the original protoplanetary disc to its current state. Essentially, we take the scientific process for understanding celestial phenomena and use that to build the galaxy in-game.'

At the core of Elite's galaxy generation software is a tool known as the Stellar Forge, which had to be created by the developers. 'Designing the system started with amassing the latest research into all the relevant fields, such as galaxy mass distribution, stellar and planetary evolution and a host of fun and esoteric subjects. That was then condensed into algorithms that can be applied at runtime to generate the details that are then represented in the game.' Alongside this more general data, the Stellar Forge also supports data from around 150,000 real stars and around 5,000 known exoplanets.

Until recently, the Stellar Forge's main concern was the fundamental properties of celestial spheres, and how they interact with space and other celestial bodies. For example, in a single solar system, the Forge's primary concerns would be the size and class of the star, and the orbits and elemental makeup of the planets within the influence of its gravity. Recently, however, the Forge has had to contend with a lot more data in preparation for Elite Dangerous' Horizons expansion, which will allow players to actually land on planets and explore their surfaces in terrestrial vehicles.

ESSENTIALLY, WE TAKE THE SCIENTIFIC PROCESS FOR UNDERSTANDING CELESTIAL PHENOMENA AND USE THAT TO BUILD THE GALAXY IN-GAME

Frontier is applying the same level of scientific accuracy to its planetary surfaces. The basic surface is formed from a series of values provided by the

Planetary landings will include new vehicle types, quests and combat opportunities

Stellar Forge's galactic data; information related to the planet's orbit, classification and elemental nature. 'There are large correlations between many of the values, such as gravitational stress, crust thickness, mantle temperature and rift formation,' says Brooks. 'As these values are averages to be shared across the entire planet, based on planet and system-wide variables, they can be processed in very short order on the CPU as the star system is loaded.'

From this point, several tools mathematically determine the specific surface features of the planet. 'One of the first things produced is a mask on the surface, which highlights areas where we'd expect hill formation to occur. The shape of these regions depends on various average values we calculated in the previous step, along with random numbers for variation. The mask may reflect the shapes of tectonic plates if that makes sense for the particular planet; otherwise, it may be associated with areas of existing larger scale deformation,' Brooks explains. 'Another module that produces the actual hills has another series of functions, which produces hills with height, frequency and slope controlled by the average values for the planet.'

The Stellar Forge isn't simply calculating this information, but simulating it for the planet over time, even taking into account variables such as the tidal forces placed on the planet by a nearby object such as a moon, right down to the planet's core. 'The tidal locking also enters the noise modules as an input,' says Brooks. 'As the facing side of a tidally locked moon will be relatively shielded from meteorites, a tidal locking mask module suppresses craters on that side.'

Games such as Elite Dangerous demonstrate how far we've come in terms of creating virtual worlds via procedural generation. Indeed, it's fair to say we've gone beyond 'worlds' entirely, creating algorithms and processes that can simulate the gestation of entire galaxies.

The unpredictability bonus

However, using procedural generation as a sculpting tool is only half the story. An important aspect of procedural generation is that you don't always know what's going to fall out at the far end of the pipeline. This situation can be problematic, but it can also provide inspiration and result in entirely new features, which is what happened with The Swindle.

'Early on, it was generating these madcap levels with 100ft drops and even I know that's not how buildings work,' says Dan Marshall. 'So I tweaked the algorithm to generate more realistic buildings and the game became less fun – the stupid designs were much more fun to navigate.' Even in a game that has a scientific approach, such as Elite Dangerous, the Stellar Forge outputs some pretty wild creations. 'There are 'hell worlds' that are so hot that their atmospheres are gaseous metals,' says Brooks.

For some games, procedural generation isn't a means to an end – a technique to make a new building or galaxy to explore – but the driving force behind the entire experience. Perhaps the most notable example is Bay 12's Dwarf Fortress. A game that's been ten years in the making, with possibly another 20 years to go, Dwarf Fortress sees players assume control of a team of dwarves, who are given commands to build and manage a fortification in an astonishingly complex, procedurally generated world.

Top: A render of a standard Dwarf Fortress world. A fortress would occupy a tiny fraction of the above area

Above: Like everything else, combat in Dwarf Fortress is described in intricate detail

THERE ARE 'HELL WORLDS' THAT ARE SO HOT THAT THEIR ATMOSPHERES ARE GASEOUS METALS

To give you an idea of Dwarf Fortress' complexity, its co-creator, Tarn Adams, explains his creative process. 'You make the little pieces as small as you can make them, so you're comfortable that they're communicating what you want them to do, but they're not so granular that they kill your CPU. You get them down to a certain stage and then interrelate them,' says Adams.

'The Dwarf is built out of its body, but its body can be different sizes and its body has wounds. Different people have thoughts, family relationships, a personality profile, jobs they're good at, their attributes and all the items they're carrying. Then the body has materials, and the materials all have properties such as tensile strengths. Tensile strength wasn't originally in the game, and then it came up so it was added.'

This is the scale with which Bay 12 Games is working, and this meticulousness is applied to every aspect of Dwarf Fortress. Each new game of Dwarf Fortress begins with a procedurally generated history simulated via a turn-based strategy game the computer plays with itself before the player even sees the world. Dwarf Fortress even has procedurally generated poetry analysis, which describes the poem's structure and what it's intended to convey to the player in detail.

Procedural storytelling

What's the point of this absurd level of detail? The answer is simple – to create stories. Dwarf Fortress uses extremely basic ASCII graphics and has a finicky and unintuitive control system, so everything that happens in the game is described in text. Every game of Dwarf Fortress results in an intricate fantasy story about the lives and deaths of the dwarfs in your fortress. The monsters they encounter, the heroic deeds they perform and the wounds they suffer all emerge from the game's procedural systems, and are unique and exclusive to the scenario generated in your game.

This has been Adams' goal since before Dwarf Fortress, when he and his brother made games together to

AT WHAT POINT DOES SOMETHING THAT IS GENERATED BY A COMPUTER, A MINDLESS MACHINE, BECOME MEANINGFUL AND SIGNIFICANT?

These painting-like scenes in Forest of Sleep are fully animated

entertain one another. 'As long as the computer can give you a number between one and ten, it can give you anything. It's not going to have the subtleties and symbolism that a human author might create. It won't be as finely crafted as someone's masterwork, but that wasn't an issue with the games we were playing at the time.'

Adams' words hint at the last big challenge for procedural generation, one which, as is clear in his statement, is potentially insurmountable – creating a meaningful experience through procedural generation. Games that emphasise emergent play through generative content are capable of producing brilliant little stories, but they usually revolve around the same basic themes. In a game such as The Swindle, it's about how you escaped or didn't escape with the loot. In Elite, it's that time you evaded a group of space pirates, or smuggled valuable cargo into a space station undetected. Even in a game as intricate as Dwarf Fortress, the stories it creates are about events that happen rather than what those events mean.

It's this notion of adding meaning to a generated experience that Ed Key plans to explore in his next project, Forest of Sleep, a narrative exploration game inspired by Russian fairytales. The game places you in control of three young boys travelling through a forest, where they encounter characters who can set them on adventures.

The game uses a careful blend of procedural and authored content, which is reflected in the art style. Its evocative 2D woodland scenes are constructed from layers hand-drawn by artist Nicolai Troshinsky, which are then stitched together by the game's procedural engine. These scenes are themselves connected procedurally into a larger map of the world.

'We have this idea with the map screen where you can, at certain points in the story, say to the player, "you have to go to this place", and it will be somewhere far away on the map. And the game can react to the player either going towards that place or going away from it,' Key explains. 'If they're going away from it, that probably means they want to add new story elements and they want to make it more of a sort of road movie, or a story about disobeying what you're supposed to be doing.'

Your adventure in Forest of Sleep will see you encounter all manner of strange individuals

You can respond to characters' conversations in different ways, which will affect how the story progresses

Key describes the relationship between the player and the game in Forest of Sleep as being reminiscent of the relationship between player and Dungeon Master in a game of D&D. There are key plans for the game to analyse your patters of play and use that information to either continue with a certain thematic motif or deliberately invert it. Characters you encounter early in the game might be encountered later, and may act differently toward you depending on how you treated them the first time.

Forest of Sleep will convey its story entirely through visuals, animation and gestures, with no written dialogue or voice acting. The idea is to give the player the broad strokes of the adventure and the character interactions, and let them fill in the details of what those interactions mean. 'The thing I keep asking a lot about procedural generation,' says Key, 'is at what point does something that is generated by a computer, a mindless machine, become meaningful and significant?'

That's the question that procedural games are yet to answer. We know that basic random number generators can result in remarkable landscapes, entire galaxies and delightful story engines, but can a random number convey a message? It seems ridiculous to ask, and yet, looking at how far procedural generation has come, such a feat seems closer than ever before. **RPS**

GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

REVIEW
Compulab Fitlet

Do you remember when you first saw the Intel Next Unit of Computing, and thought, 'Blimey, that's small?' When the Fitlet arrived from Israel-based Compulab, I had a similar reaction made more impressive by the fact that the box I thought would be dominated by the machine itself was in fact mostly full of cables, accessories and a wall-wart PSU. If you need a small yet powerful computer, the Fitlet measures 108 x 83 x 24mm (W x D x H), with a volume of 0.215 litres. The smallest NUC model, by contrast, measures 115 x 111 x 32.7mm with a 0.417-litre volume.

Despite fitting – just about – in the palm of your hand, the Fitlet packs a full quad-core AMD APU and plenty of ports

Before you get too excited, though, there's a disparity in performance to consider. The Intel NUC5i5RYK packs an Intel Core i5-5250U 1.6GHz dual-core processor; the Fitlet tops out with an AMD A10-Micro6700T 1.2GHz quad-core Mullins processor. On the plus side, the AMD chip has just a 4.5W TDP next to the Core i5-5250U's 15W. However, the AMD chip is much slower, achieving only half the real-world performance of the Intel chip in CPU Mark.

Still, half the performance at less than a third of the TDP is nothing to be sniffed at, and the AMD chip – originally designed for compact, low-cost laptops – is more than powerful enough for desktop use and even light gaming, thanks to an accelerated processing unit (APU) design that includes Radeon R6 graphics with 128 stream processors running at 500MHz.

The Fitlet model reviewed here represents the top offering. It has 4GB of DDR3L memory and a 64GB mSATA SSD factory-fitted, and you can upgrade them to 8GB and whatever capacity you like respectively. Bare bones models are also available, with the cheapest dropping to an AMD E1 Micro-6200T 1GHz dual-core processor for buyers on a budget.

A model with Linux Mint is available, but you can opt for Windows or install your own OS instead

You're not buying a Fitlet for raw performance though – you're buying it for a combination of flexibility and size. It's in this respect that the spec sheet really starts to impress: the top-end model, as reviewed, includes three external USB 2 and two USB 3 ports, eSATA 6Gbps, two HDMI 1.4a outputs and a micro-SD slot.

There are also two Gigabit Ethernet ports hanging off an Intel I211 controller, dual-band 7260HMW 802.11ac Wi-Fi with twin external

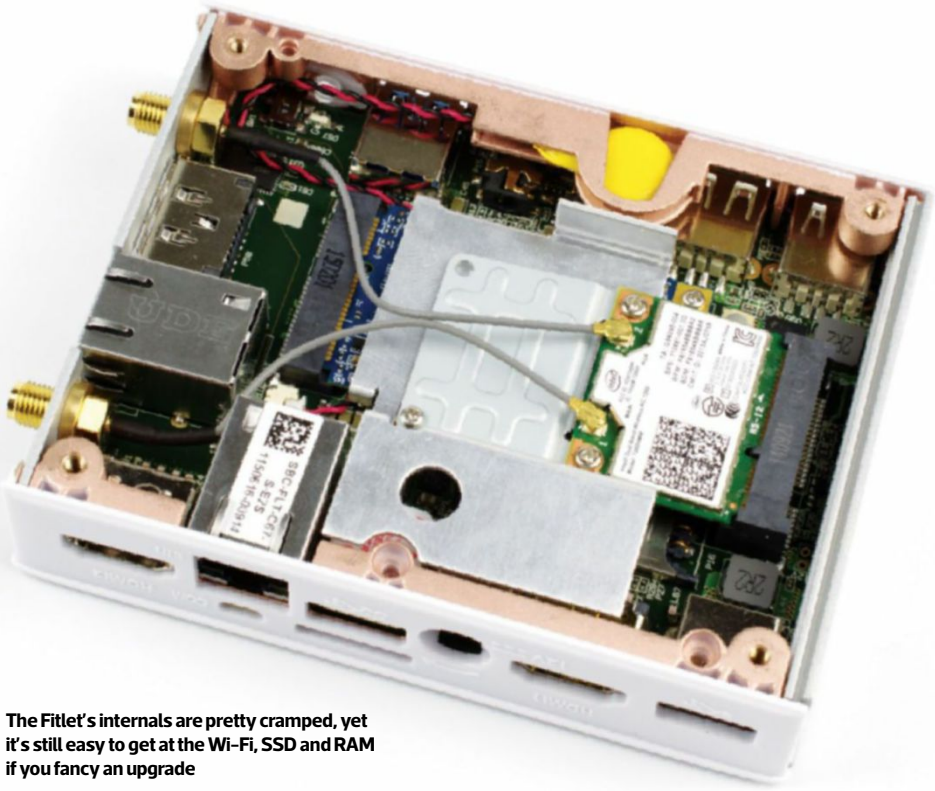
The case has metal top and bottom panels, acting as a heatsink for this entirely silent system

antennae and built-in Bluetooth 4.0, a mini-serial RS232 port and even a mini PCI-E slot for internal expansion, plus analogue and S/PDIF digital inputs and outputs.

In short, while its raw performance may be lacking there's no shortage of flexibility – and we're talking about a machine that's not much larger than a cased Raspberry Pi here. There's even a 14-pin 3.3V-logic GPIO connector, which requires an optional breakout cable but is otherwise accessible without opening the chassis. Sadly, however, at the time of writing, Compulab's engineers were still working on drivers to enable GPIO access in Linux and Windows, so I wasn't able to test this feature.

Nevertheless, there was plenty to keep me interested in the Fitlet. The case, in particular, has a clever design, with metal top and bottom panels acting as a heatsink for the passively cooled, entirely silent system. Compulab even includes an optional replacement lid featuring far larger fins for more demanding thermal environments, or for people who want to play around with the overclocking function built into the BIOS, which enables you to set a target TDP of up to 25W for the APU. Testing showed that it isn't a gimmick either: setting a 10W target TDP saw an appreciable improvement in real-world performance, with diminishing returns past that point.

Compulab is also serious about supporting the Fitlet community with plenty of accessories. As well as the GPIO cable and heatsink, the company offers VESA mounts and DIN rail mounts for rack applications. Plus, there's even a pre-wired remote power switch for out-of-the-way applications.



The Fitlet's internals are pretty cramped, yet it's still easy to get at the Wi-Fi, SSD and RAM if you fancy an upgrade

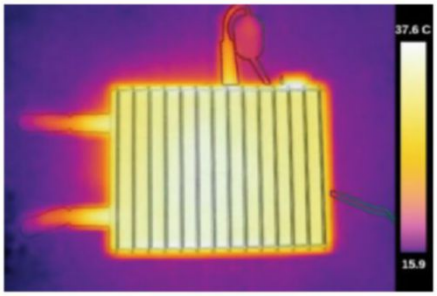
The review sample was pre-loaded with Linux Mint 17.2, under which the Fitlet performed admirably. The network interface, in particular, impressed me, compared with the usual ARM-based boards I test, with a real-world throughput of 891.9Mb/sec.

However, folks used to seeing reviews of low-cost single-board computers in this column may want to sit down for this next bit, because it's time to discuss price. In bare bones configuration, the entry-level Fitlet B costs a relatively reasonable $129 plus shipping and VAT direct from CompuLab, while the Fitlet iA10 unit on review here, minus RAM and SSD, will set you back $299.

If you buy your Fitlet from UK stockist **www.tinygreenpc.com**, those costs work out at £156 and £300 respectively – putting the Fitlet iA10 in the same price league as Intel's more powerful NUC5i5RYK, albeit in a smaller form factor and with added extras such as the second Gigabit Ethernet port, eSATA and GPIO when software support arrives. If those features and/or the smaller size aren't your top priorities, though, the NUC5i5RYK is the more powerful machine. More information is available at **www.fit-pc.com**

An Intel Wi-Fi card is routed to two RP-SMA connectors with bundled antennae

The Fitlet GPIO cable is lovely, but at the time of writing, there was no software support available



The metal casing does a great job of dissipating heat, and the entire unit is passively cooled and silent

REVIEW

Bare Conductive Touch Board Starter Kit

Last month I discussed Rachael Moat's musical bowls that I saw at Manchester MakeFest – conductive audio-playing magic that helps children with special educational needs to broaden their dietary horizons – and promised that I'd be reviewing the hardware that made it happen. Here, then, is that review, of the Bare Conductive Touch Board Starter Kit.

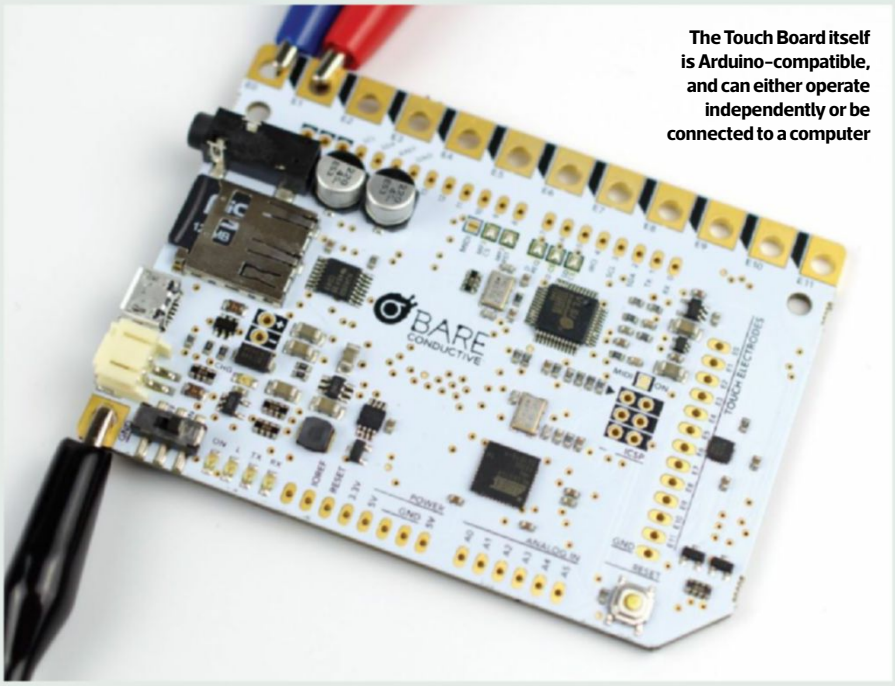
Bare Conductive got its start with a clever formulation for conductive paint. The concept isn't new – small pens of silver liquid have long been used to fix electrical breaks in heated car windscreens, while scribbling graphite pencil onto card to conduct electricity is a common school experiment. However, the company's primary products – a pen-type squeezy tube and a larger pot for brush application, have proven effective and popular in the maker market.

The follow-up was the Touch Board, an Arduino-compatible microcontroller built specifically for touch sensing. Combining several features it would normally take additional boards to achieve, the Touch Board offers 11 large contact points for connection to conductive thread, the company's conductive paint, wires or the tip of your finger.

When a touch is sensed, the board fires off one of the MP3 files stored on a bundled micro-SD card through a 3.5mm headphone jack. If that's all you want to do, there's no more programming involved – just build your circuit and replace the MP3 files with your desired sounds. Otherwise, fire up the Arduino IDE and start hacking; all the usual pins and features are present and correct on the board, as well as the touch-sensitive and music-playing functions.

The beefy box gives buyers a taste of the included projects' scale

The Starter Kit is really a showcase, bundling all the company's products together in one terribly well-thought-out pack. Inside the oversized box, you'll find a pot of conductive paint and a brush for wide-area application, a squeezy tube of the same material for finer control, the Touch Board, a micro-SD card, a micro-SD reader, colourful wires with crocodile clips, a rechargeable amplified speaker and – oddly – a stencil of a house and a pair of shaped paper cut-outs.

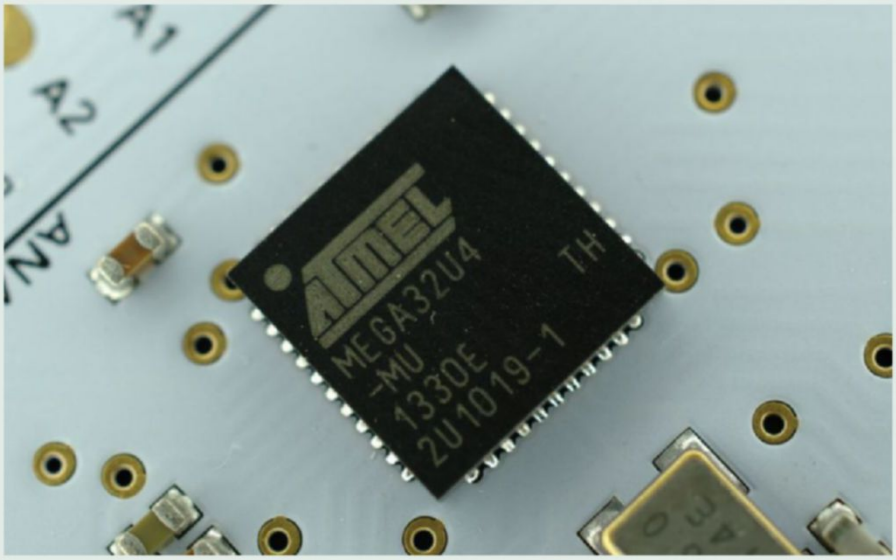


The Touch Board itself is Arduino-compatible, and can either operate independently or be connected to a computer

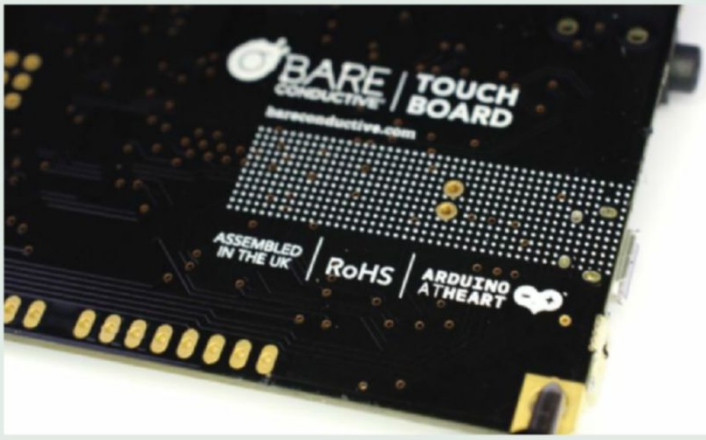
The latter forms the first project of a bundled three-project, full-colour guidebook. Wonderfully designed, the guidebook walks a newcomer through the setup process and uses the stencil and paper cut-outs, along with bundled sticky tabs and Velcro, to demonstrate one use of conductive paint: a diagram of a house, mounted directly to a wall, which fires off sound effects when particular objects are touched.

The remaining two projects are in a similar vein; the second demonstrates how the Touch Board can trigger playback when objects such as a houseplant or photo frame are touched, while the last creates a sort of burglar alarm – albeit one that's only likely to operate if the thief is barefoot, a problem neatly circumvented in the picture demonstration with the use of a dog instead.

The most impressive aspect for a newcomer, though, is that the Touch Board itself acts as an introductory guide. You simply connect it to micro-USB to hook up the power and speaker (or a headphone) and then press the first touch contact point to hear



The use of an Atmel ATmega microcontroller and standard bootloader means the Touch Board is entirely compatible with the stock Arduino IDE



The UK-built Touch Board wears its Arduino inspiration on its sleeve – or, rather, the rear silkscreen layer of the PCB

The full-colour guidebook may only have three projects, but they keep you amused and engaged

Two containers of conductive paint are included – one for brush use and the other acting like a pen for finer applications

a welcoming message. It then talks the listener through the features and use of the board – a really neat touch, and one that helps to humanise the otherwise scary magic tech that could put off non-technical types.

That isn't to say that the Touch Board is only suited to newbies though: at its heart, it's a fully fledged Arduino system and you're able to reprogram it as you see fit. If you'd rather trigger external hardware when touch is detected, the usual analogue and digital pins are present and correct as a foundation on which you can build; it's even possible to program the board as a non-contact distance sensor if you'd prefer.

You aren't limited to using just the paint either: any conductive material, including conductive thread, works just fine with the Touch Board, as does the fruit more commonly associated with the rival Makey Makey board. It's even possible to use a subset of Arduino Shield add-ons to further extend your projects, and there's a guide to what does and doesn't work in the back of the bundled book.

The only real reason for not picking up the Touch Board Starter Kit is the price. At £95 inc VAT, it's above the cost of an impulse buy for most hobbyists, but it's also hard to say how the cost could easily be reduced: the Touch Board alone costs £55, while the conductive paint adds a further £24 to the mix – and that doesn't leave a great deal for the speaker, card reader, cables, brush, stencil and full-colour booklet.

If you're looking to get kids involved in electronics, it's a great kit, and the paint is easily washable with soap and water for the inevitable mess they'll make.

However, for anyone merely curious about the potential of conductive paint, pairing a £6 tube of Bare Conductive's finest with a cheap Arduino Uno or clone will prove a more affordable introduction.

The Bare Conductive Touch Board Starter Kit is available now for £95 inc VAT from **www.bareconductive.com**

NEWS IN BRIEF

Netflix releases homebrew switch

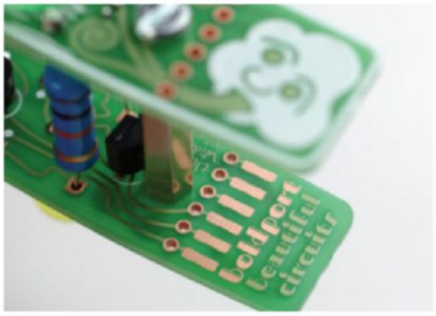
Not a name you'd readily associate with the maker market (aside from that NES video streaming cartridge hack a while back), Netflix has released plans for a Netflix Switch, which automates the already pretty automated process of kicking back and streaming some films. Based around a Particle Core (formerly Spark Core) microcontroller, the reference design is little more than a dedicated and bulky remote control, with the company encouraging the community to add more features such as pizza ordering or smart-light dimming. Information on the project is available at **http://makeit.netflix.com**

REVIEW

Widdop

London-based Boldport is an electronics firm with a difference. Its founder, Saar Drimer, believes that circuits should be both functional and beautiful, and eschews the fixed 45-degree angles and parallel lines of modern CAD packages. Instead, he created his own circuit design software, PCBmodE, which allows him to build elegant circuits on oddly shaped – and often animal-themed – boards with flowing traces and graphical elements.

To demonstrate his skill in circuit art, Drimer has released a series of kits aimed at the hobbyist – and one of them is a deliberate mystery. Dubbed the Cordwood, it's both a soldering kit and a puzzle; the buyer gets a bag of components and a pair of identical circuitboards, and it's up to them to figure out how it all goes together, and even how to use it once it's assembled.

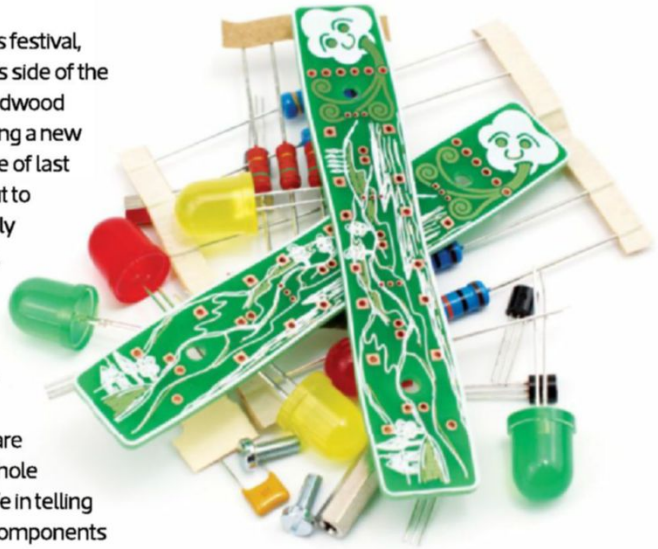


Crocodile clips can be connected to these pads, but you'll have to work out the right order yourself

For this year's Wuthering Bytes festival, the premier technology event this side of the Pennines, Drimer designed a Cordwood variant called the Widdop, featuring a new design bringing in the wind theme of last year's Wuthering Bytes. Given out to attendees, the Widdop was strictly limited and is no longer available, but it's functionally equivalent to the Cordwood.

So, how can I let you know what it does without giving away the puzzle? It's safe to say it's designed to light up LEDs; there are six traffic light-themed through-hole LEDs included in the pack. I'm safe in telling you that the idea is to sandwich components between the two attractive circuitboards too: a quick Google of 'cordwood construction' would reveal that trick. The bundled stand-off pillars take care of the distance between the two boards too, but to offer you too much insight into the assembly process would ruin the heart of the game.

So, to summarise: you carefully solder the transistors, pins, screws, pillars and resistors included in the pack together – an interesting experience, given the three-dimensional layout – in a way that means the LEDs light up when voltage is applied. You'll see no full pictures of the completed kit, nor even the assembly process, here: if you're that curious, pick up a Cordwood and try it yourself.



See this pile of parts? The aim is to build a working, microcontroller-connectable circuit from them

The fun really begins when you tie the circuit into a microcontroller or microcomputer. Using the clip-friendly contact points or breadboard-friendly pins, you can control each of the six lights individually - but, of course, there's no handy labelling to let you know the purpose of each pin. That situation didn't prevent attendees at Wuthering Bytes from having a go, though, with my personal highlight being the sight of Daniel Bailey interfacing the Widdop with his home-brew 8-byte – not a typo, and you'll be hearing more about that project in the future – microcomputer, the C88, and cycling through the LEDs individually.

I'm a big fan of Drimer's circuit designs – and you can expect to read a full interview in a future column – and both the Widdop and Cordwood appeal to the hacker in me. They're not kits for everyone – absolute beginners with no knowledge of electronic circuits may find the process frustrating – but for anyone who fancies flexing their skills in a novel way, the Cordwood is easy to recommend. Just make sure you think the circuit through before soldering any of the components into place!

While the Widdop is a limited edition exclusive to Wuthering Bytes, the original Cordwood can be purchased as a self-assembly kit direct from **www.boldport.com** for £20 inc VAT. CPC

NEWS IN BRIEF

Arduino Wi-Fi Shield 101 launches

The official Arduino Wi-Fi Shield 101 add-on, built by Arduino.cc in partnership with Atmel, has finally launched, more than a year after it was first announced by the company. Currently a US exclusive, the $49 price tag is considerably less than the original Arduino Wi-Fi Shield while adding on-board cryptographic authentication through a dedicated ATECC508A co-processor. Based on Atmel's WINC1500 radio module, the shield is compatible with all modern Arduino boards – but, sadly, confirmation of UK availability and pricing was not available at the time of writing.

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

'With moments of real genius, some of his poems will last as long as poetry is read.'

– Benjamin Zephaniah

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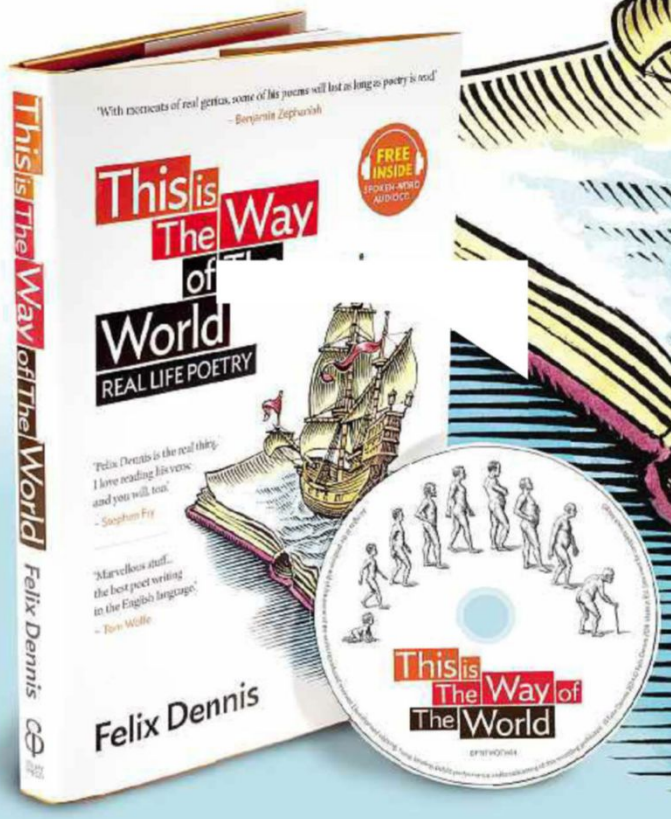

A book of poems for those who don't read poetry (as well as for those who do!)

A collection of 'real life' poems by Felix Dennis, one of Britain's best-loved poets, charting life's course from infant to endings with illustrations by Bill Sanderson.

www.felixdennis.com contains many poems, published and unpublished, as well as a library of sound recordings and video footage of Felix Dennis's verse and poetry tours.

EBURY PRESS

ANTONY LEATHER'S

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Easier and cheaper water cooling

Last month I mentioned an interesting new GPU liquid cooler from Alphacool – the GPX-Pro. I managed to get some hands-on time with it briefly at the recent Multiplay event in Coventry, and there are several reasons why it's potentially a very interesting bit of kit. Firstly, it's incredibly quiet – much more so than any all-in-one liquid cooler I've tested. Secondly, it's a far more elaborate and refined GPU cooler than NZXT and Corsair's efforts to mount their all-in-one liquid coolers on graphics cards.

Finally, and perhaps most importantly, there's scope for doing away with a mountain of hardware compared with a traditional water-cooling loop. You don't need a GPU waterblock, reservoir or pump and, as the loop is expandable, there's even the potential to also water-cool your CPU by adding a CPU waterblock.

The Predator 240's Laing DDC pump offers superior flow rate and pressure to usual all-in-one liquid cooler pumps

As a result, not only could water-cooling your CPU and GPU get much cheaper, but you could also fit the gear in practically any case, as long as there's enough room for a radiator.

It's a very promising system for small form factor PCs, as finding an appropriate location for pumps and reservoirs has always been an issue in small cases. Of course, some all-in-one liquid coolers can already fit into small cases, but usually with much higher noise levels, and usually with weaker pumps too.

At the other end of the scale is EKWB's Predator 240, which I reviewed on p17. It's a fantastic piece of kit that uses a Laing DDC pump, albeit one that's been knocked down from the usual 10-18W to just 6W, but the flow rate and pressure on offer are still way beyond what's offered by all-in-one coolers. This power is reflected in the price, but also in the cooling. I touched on its expandability in the review, but in more detail, you'd just have to drain the loop, buy a bit of extra tubing and two more fittings and you could throw in a GPU and/or motherboard waterblock too.

We've looked at expanding all-in-one liquid coolers in our How to section before, but the pumps in these coolers don't really offer enough power to handle extra waterblocks properly, and their flow rates and pressure will likely drop to levels that reduce performance too. The Predator shouldn't be overlooked because it's a ready-to-

use unit either. Personally, I get a lot of pleasure from building my own water-cooling system, but the process takes hours, or even days if you include leak testing too – the Predator avoids both of these problems, while also saving you money.

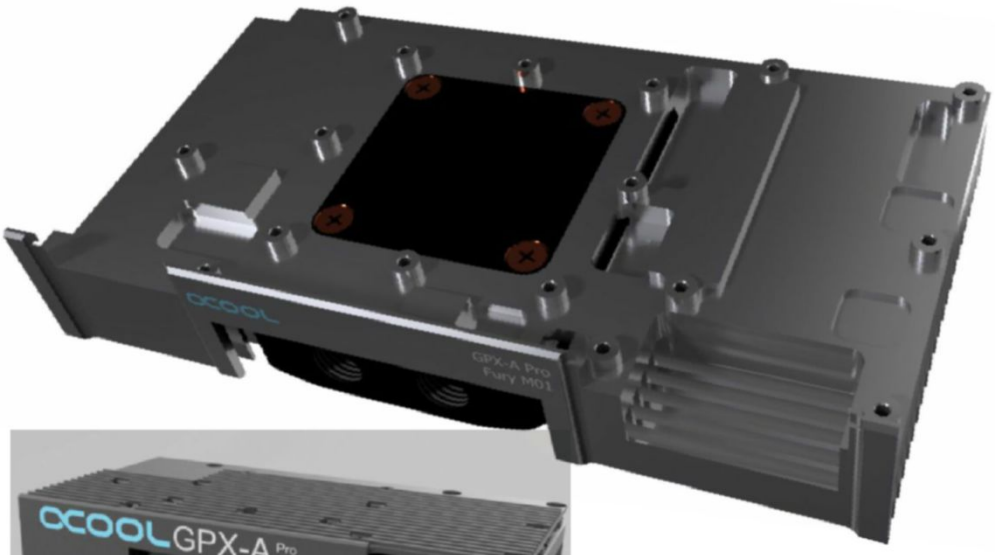
Alphacool interview

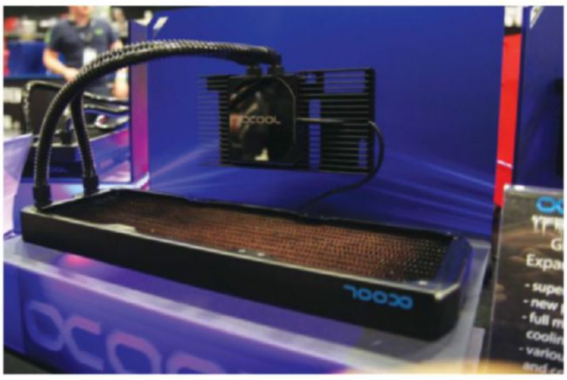
Switching back to the Alphacool GPX-Pro, though, I caught up with Alphacool and asked the company a few questions about its latest product, which is currently still in development, but should hit the shelves soon.

Antony: How powerful is the GPX-Pro's pump? Are you able to connect other hardware to the loop, for example, such as a CPU waterblock?
Alphacool: The pump is strong enough to cool a CPU, GPU and connect to a 420mm or 480mm radiator, so you can buy only the GPX-Pro and easily expand your cooling loop later.

Antony: Are the passive heatsinks the same as those on the Alphacool waterblocks? For example, would the passive heatsink on a NexXxoS GPX 390 M01 fit the GPX-Pro, or are GPX-Pro's heatsinks custom-made?
Alphacool: The normal GPX cooler doesn't fit with the GPX-Pro, because the pump on the cooler needs more space when using a passive cooler. However, if we scan a graphic card, it's easy to take that data and apply it to make coolers for both systems – the GPX and GPX-Pro. We'll start with coolers for the GTX 980, 980 Ti, Titan X and AMD's Fury range of graphics cards, and later, we'll maybe have GPX-Pro kit for smaller graphic cards. If enough people ask for them, we'll make them!

Antony: Will Alphacool offer the same custom 3D scanning service for different PCBs with the GPX-Pro as it does for the NexXxoS waterblocks?
Alphacool: Yes, but it will be a bit different to the process with the normal NexXxoS waterblocks. A complete GPX-Pro is much more expensive than a normal NexXxoS GPX cooling block – we'll have to find out how we can offer that service to our customers, but we'll do it if it's possible.





The Alphacool GPX-Pro's pump is strong enough to cool a CPU and GPU, and to connect to a 420mm or 480mm radiator

Antony: What issues have you encountered so far, and when can we expect retail versions?
Alphacool: Well, on the Fury X, we've found that AMD's high-bandwidth memory needs different cooling power than normal GDDR VRAM, as there's a much bigger heat spot around the GPU. That was a reason for us to make a better and bigger contact point between the cooler and the passive heatsink. In fact, the passive part isn't really passive; it's being cooled by the waterblock, which makes direct contact with the heatsink.

The MOSFETs are also very hot on the Fury X, so we needed to make better contact between the cooler and the graphics card. We had been using thermal pads on the GPU side of the PCB, but with the newer version, you only need thermal paste between the cooler and the card.

Thermal pads have much more heat resistance than thermal paste – they're just not as good. We're talking about 20°C cooler performance for the MOSFETs between the old version of the GPX-Pro and the new version– you can see the latest renders of the new model above.

There are a few more parts we'll change to achieve better performance too, but we're keeping those changes under wraps for the moment. One result of making all these improvements is that we've had to completely change the tooling of the cooler, which is why we don't expect to release it this year. The plan is to have a retail-ready version in early 2016.

Thanks to Alphacool for taking the time to talk to us. I'll hopefully have my own pre-production GPX-Pro sample to show you soon, and once the final version is ready, we'll have a full review in **Custom PC**. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Relocate your case's PSU mount

Antony Leather shows you how to move your PSU to make way for bigger radiators

TOTAL PROJECT TIME / 3 HOURS

Most cases have a good deal of water-cooling support these days and for good reason – all-in-on liquid coolers are more popular than ever, so it isn't just water-cooling enthusiasts that look for cases that can house large radiators. However, while the likes of Corsair's H75 – a single 120mm-fan radiator cooler – can sit happily in a rear 120mm fan mount, many cases lack compatibility with double, triple or quad 120mm-fan radiators.

The problem isn't a lack of space, but a reluctance to step outside traditional case design. For example, the PSU is almost always located at the rear of the case, wasting a huge amount of space, especially if it's at the top. This situation is particularly annoying in small cases, where space is at a premium. However, it's fairly simple to relocate your PSU using some basic tools and materials – you can even swap to a smaller SFX PSU to save even more space.

TOOLS YOU'LL NEED

Metal file / Most hardware stores

1.5mm aluminium sheet / www.ebay.co.uk

Dremel or jigsaw / Most hardware stores

Kettle lead port / www.ebay.co.uk

Drill and drill bits / Most hardware stores

Angled power lead / www.ebay.co.uk

1 / Check for benefits

There's no point in moving your PSU if you won't gain any benefits by doing so. In our case, removing it from a roof mount clears the whole roof area for mounting a radiator.

2 / Inspect PSU area

To cover the gaping hole in the PSU area, you'll ideally need to rivet a piece of aluminium in place. This job is easily achieved, but make sure there's enough space at the edges to insert the rivets.

3 / Check material thickness

As well as checking space at the edges, you'll need to make sure the steel or aluminium in this area isn't too thick. Thankfully, most case materials are never more than 5mm thick, but beware of any areas that are double-skinned.

4 / Choose relocation area

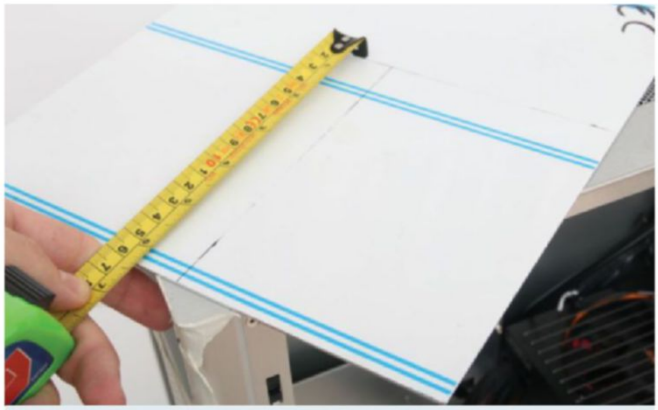
Before you start cutting and riveting, make sure there's a viable place to relocate your PSU. You might want to remove drive bays at the front of the case, for example, so make sure these parts can be removed.

5 / Check for mount clearance and orientation

You'll need to create a small mount for the PSU to hold it in place, so make sure there's enough room for such a mount. You have various options when it comes to mounting, but you'll most likely want the cables pointing towards your hardware.

6 / Mark up old PSU mount area

To work out how much aluminium you need, mark up the area, accounting for enough space for the rivets and for the panel to fit neatly over the top. Aluminium sheet is fairly cheap but there's no need to buy more than you need.



7 / Mark up aluminium sheet

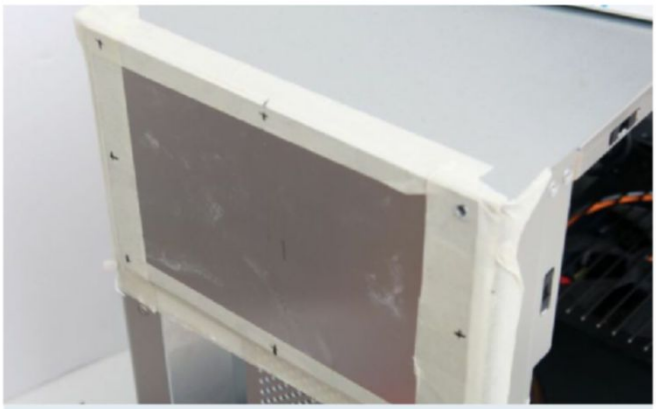
Now you know the required size of the panel, mark up the aluminium sheet by first laying down some masking tape, then drawing over the top. The masking tape will prevent scratches, which is important if you won't be painting it afterwards.

8 / Cut aluminium sheet

You can use a jigsaw or Dremel to cut the aluminium sheet. You'll probably just be dealing with straight lines, but be sure to wear protective goggles and watch out for splinters.

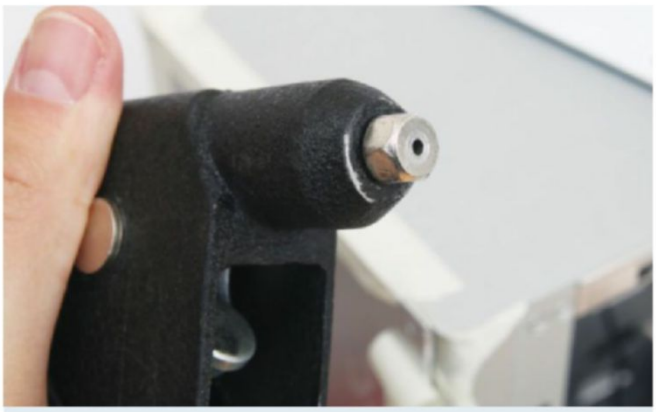
9 / File edges

It's essential to use a metal file to remove with the sharp edges on the aluminium created by your cutting tools. You can apply masking tape to the area surrounding the cut to prevent scratches.

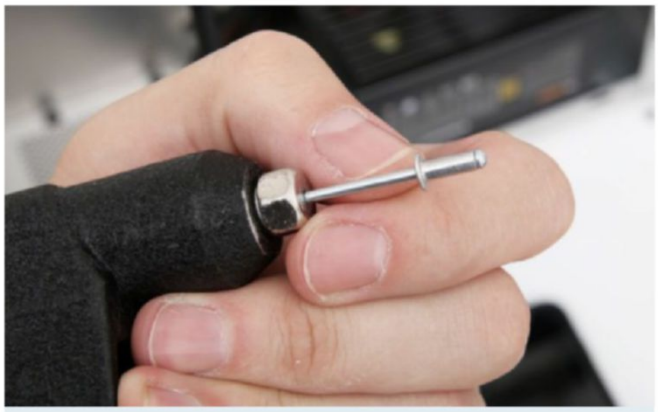


10 / Mark up rivet holes
With the panel finished, line it up on the case and mark up the rivet holes. They need to be positioned a few millimetres away from the edge on both the panel and the case's PSU mount.

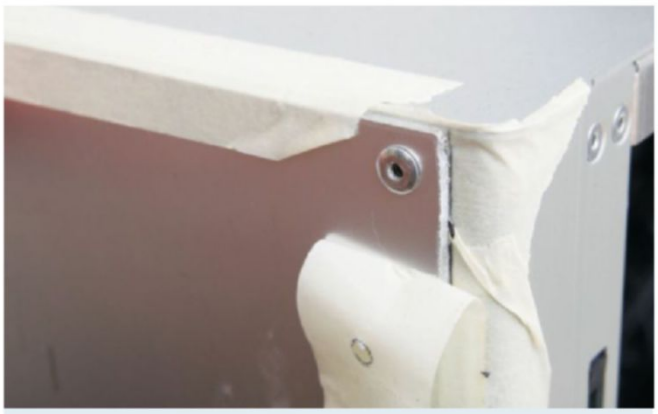
11 / Drill rivet holes
Unlike the process of tapping a screwhole, you can make rivet holes the same size as the rivets so they're a snug fit. Start by taping the panel to the case, and then drill a single hole through a corner of the case and panel at the same time.



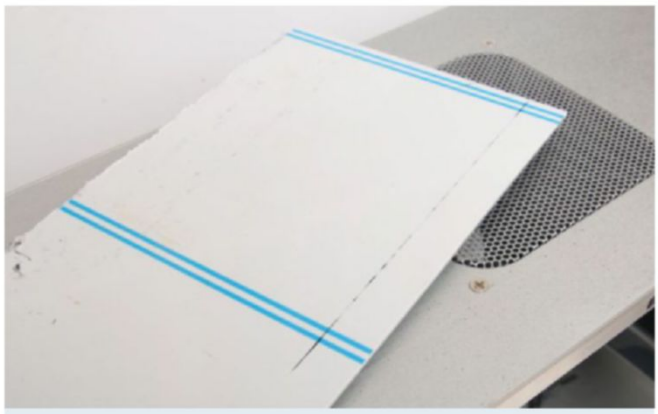
12 / Insert correct rivet head
Rivet guns come with various head sizes to match the thickness of rivet tails you'll be using. Use the correct one for your size of rivets – in our case, the tails have a 2mm diameter.



13 / Place tail into riveter
The tail of the rivet should easily pass into the rivet head – if not, you can usually adjust the gun to be a little looser using a small screw behind the head.



14 / Rivet aluminium in place
With the aluminium in place, insert the rivet head and squeeze the trigger several times with a good deal of force until the rivet snaps into place. Repeat this process for the other three rivets.



15 / Mark up mount supports
Now it's time to relocate the PSU. We've chosen a place in the front of the case at the bottom. We'll be using two L-shape brackets to secure the PSU in place.

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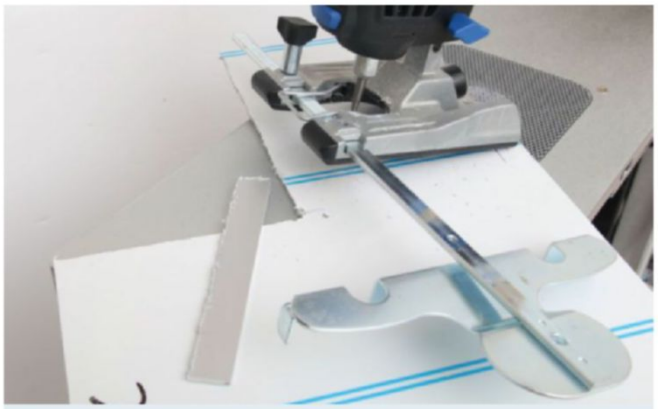
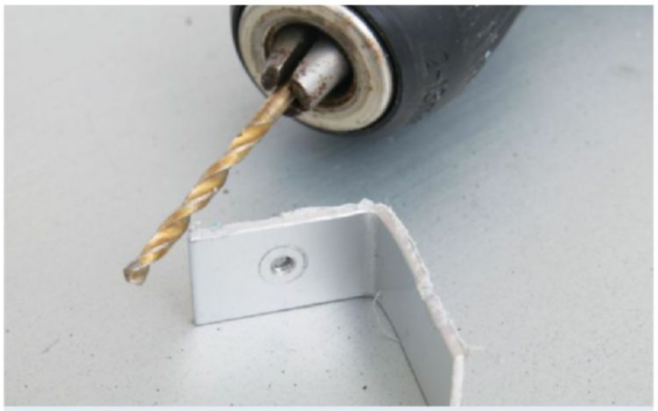


16 / Cut out supports

Once you've marked up the aluminium sheet with the size of supports you need, go ahead and cut out the required size of sheet with a jigsaw or Dremel before filing the edges smooth.

17 / Bend to shape

As we're using L-shape brackets, they now need to be bent into shape. You can bend them using the right-angled edge of a solid object. It's a good idea to use aluminium to create these brackets, as it's much easier to bend than steel.



18 / Drill mounting holes

Once you've bent the brackets, put them next to the PSU and line them up so that their bases are level with the PSU base. You can now mark up the position of the holes needed to secure the brackets to the PSU, and drill them out.

19 / Secure to PSU

You can now secure both brackets to the PSU. Most PSUs need 6-32 threaded screws (the same as case screws), but some PSUs use M3 screws.

20 / Fix in place

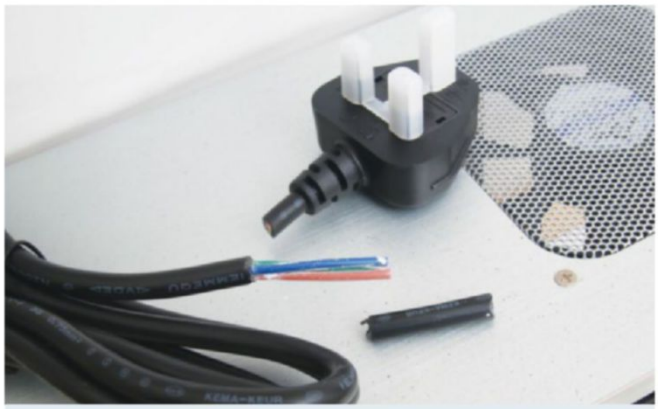
Now place the PSU and brackets in the position you need them in the case. If needs be, secure the PSU in place using some tape while you drill the final mounting holes into the brackets.

21 / Drill through to case

This time, the holes need to be slightly smaller than 6-32 screws to allow them to tap into the mount material from the underside of the case and secure the PSU. A 2.5mm drill bit is perfect for this job, as the diameter of 6-32 screws is around 3.2mm.

22 / Secure PSU

Using two standard 6-32 screws, secure the PSU to the brackets. You might need a little force and a sturdy screwdriver to tap the screw into the case the first time. If it's too tricky then you could also consider using a 6-32 tap.

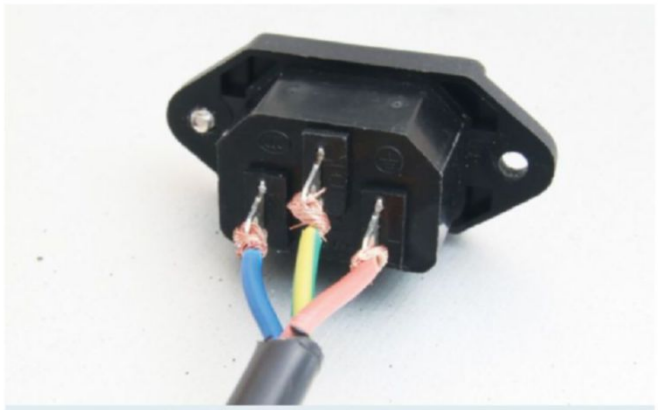


23 / Strip off plug

You can route the power cable from the PSU straight out of the case, but we're creating a custom power socket – only attempt this job if you can wire a plug and fully insulate the exposed wires. Cut off the plug and strip the cables by 1-2in.

24 / Fit power lead port

You'll need to cut out an appropriately sized hole for the port and secure it with two 6-32 screws using a similar method to the PSU mounting brackets. Make sure it's held tightly in place, as it will need to tolerate a fair amount of force.



25 / Wire up port

The three pins are wired exactly the same as a 3-pin plug. Facing the pins, the top pin is earth, the lower left is neutral and the lower right is live.

26 / Apply insulating tape

Once you've wired up the pins, wrap them in a generous amount of insulating tape, covering any exposed wires in several layers, before wrapping the whole lot again in several more layers to create a single cable.

27 / Connect to PSU

We're using an angled connector at the PSU end, as it looks neat and is easy to route around the case. You can tuck the cable into corners using cable-routing holes. Use an ATX jumper to switch it on before connecting your hardware, just to make sure it's all working okay. CPC

Readers' Drives

L3pipe

Using a custom-made support frame, rather than a standard PC case, L3pipe shows off Peter Brands' hardline water-cooling handiwork in its full glory

/MEET THY MAKER

Name Peter Brands

Age 35

Location The Netherlands

Occupation Ship electrician

Main uses for PC Surfing the Web, gaming, editing photos and video, rendering, and watching movies and TV series

Likes Spending time with my family and friends, watching movies and TV series, listening to music

Dislikes Nagging people

CPC: What was the original inspiration behind L3pipe?

Peter: Ever since I started using hardline water-cooling loops back in 2010, I had the feeling I could do much more with them – it felt like playing with Lego. Back then, I'd already started thinking about an extreme system with a lot of pipes and a very complicated loop. However, since I've been mainly focused on making desk PCs recently, I never really had the time to play with that idea.

I made a very complicated hardline loop for my last desk PC, Raz3r D3sk, a year ago, though, which triggered me to do more with hardline tubing. When I broke down that project, I had a lot of fittings lying around, and I found out that one Bitspower C47 hardline fitting could hold up to 11kg. After looking at and playing around with the fittings and various pipe structures on my kitchen table, the idea for L3pipe popped right up.

CPC: Where did the name come from?

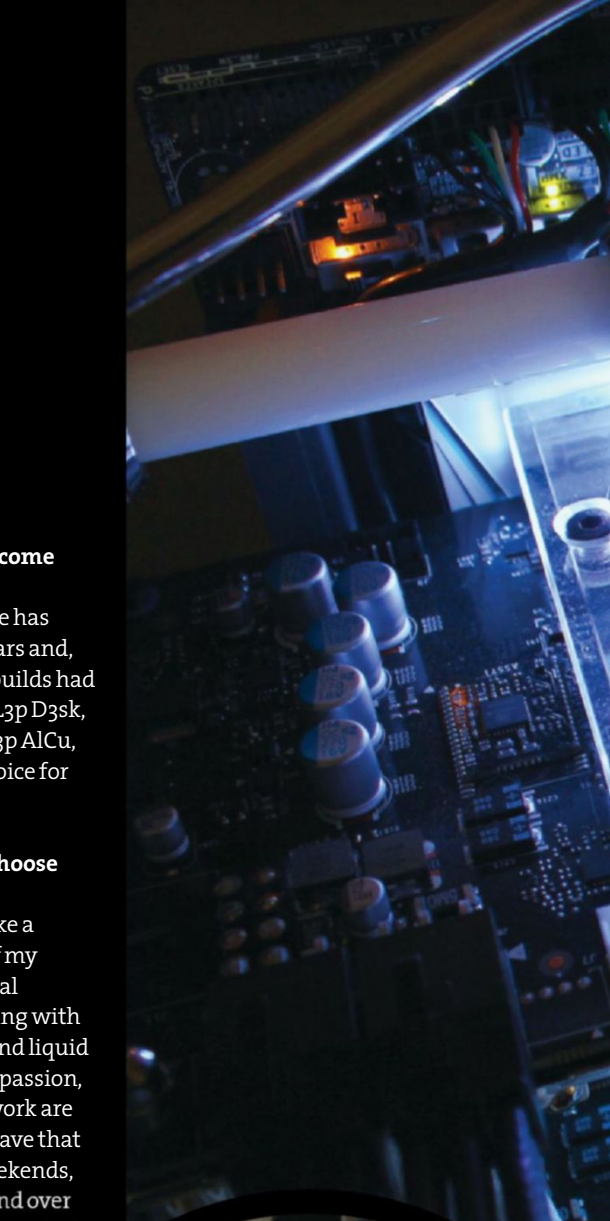
Peter: My online nickname has been 'L3p' for almost 20 years and, as several of my previous builds had L3p in the name, such as e L3p D3sk, L3p L4n, L3p Parvum and L3p AlCu, L3pipe was the obvious choice for this build.

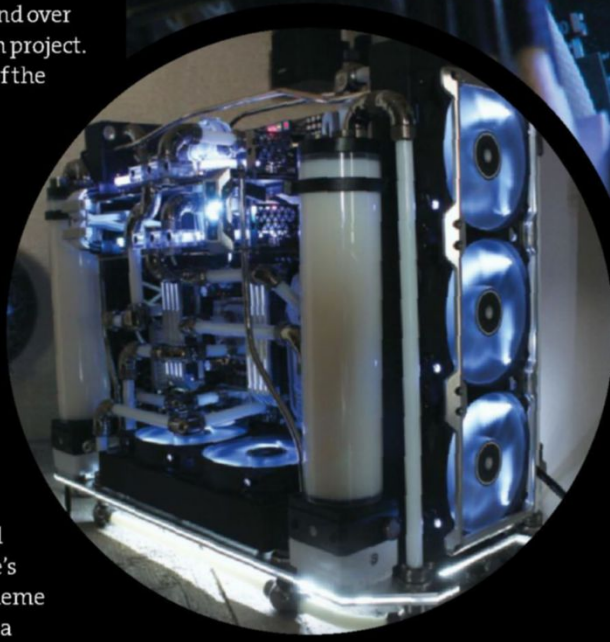
CPC: What specs did you choose and why?

Peter: This might sound like a weird thing to say, but half my builds don't even have a real purpose as PCs. I like working with hardware, case modding and liquid cooling. It's my hobby and passion, and since my family and work are my first priorities, I don't have that much time outside the weekends, which is why I usually spend over eight months making each project. With L3pipe, the purpose of the build was to play with hardline tubing, rather than the PC itself, although it should be able to handle games pretty well.

As a few well-known companies like my projects, I was offered an Asus X99 Deluxe, GeForce GTX980 cards and any kit I needed from Corsair to build it. I love to work with UV-active liquids and acrylic, but the X99 Deluxe's black and white colour scheme meant that it was time for a change, along with some inspiration from I-Robot.

The end result was my first white-themed build, with white coolant, white cables, black and white accents, and white LEDs on the clear acrylic and fans. This scheme is also complemented by chrome/nickel and aluminium tints.





CPC: What difficulties did you come across?

Peter: My first idea was to just use the fittings and PETG pipes to hold it all together. After various tests, however, I found out that it just wasn't possible to build this setup the way I wanted it. For some

SEE THE FULL PROJECT LOG: http://tinyurl.com/L3pipeLog

reason, the whole structure sank like a pudding after a few weeks, so I had to create a minimal structure to hold the motherboard, PSU, pumps and radiators. It took me a week of puzzling to figure out which parts I needed to build the structure, drawing the design in SketchUp. The awesome guys from Parvum also offered to CNC-mill and laser-cut the aluminium and acrylic panels needed for it.

The next difficulty was supporting the graphics cards, as the PCI-E slots and PETG didn't offer enough support for them. At first I thought about using an expansion slot bracket, but three weeks before the end of the project time, I found some 6mm-thick nickel-plated copper pipe at work, which is normally used in a rail system for 12V spot lights.

I also used these pipes to give the two vertically-mounted 360mm radiators more support. Finally, there was making the water-cooling loop, which wasn't really a difficulty but it did eat up my time. My wife let me take my build on vacation with me, so I could finish it there while I was relaxing.

SYSTEM SPECS

CPU Intel Core i7-5930K

Graphics card 2 x Nvidia GeForce GTX 980 in SLI configuration, with modded Nvidia 2-way SLI bridge

Memory 64GB Corsair Dominator Platinum 2400MHz DDR4, plus Corsair Dominator Platinum Light Bars

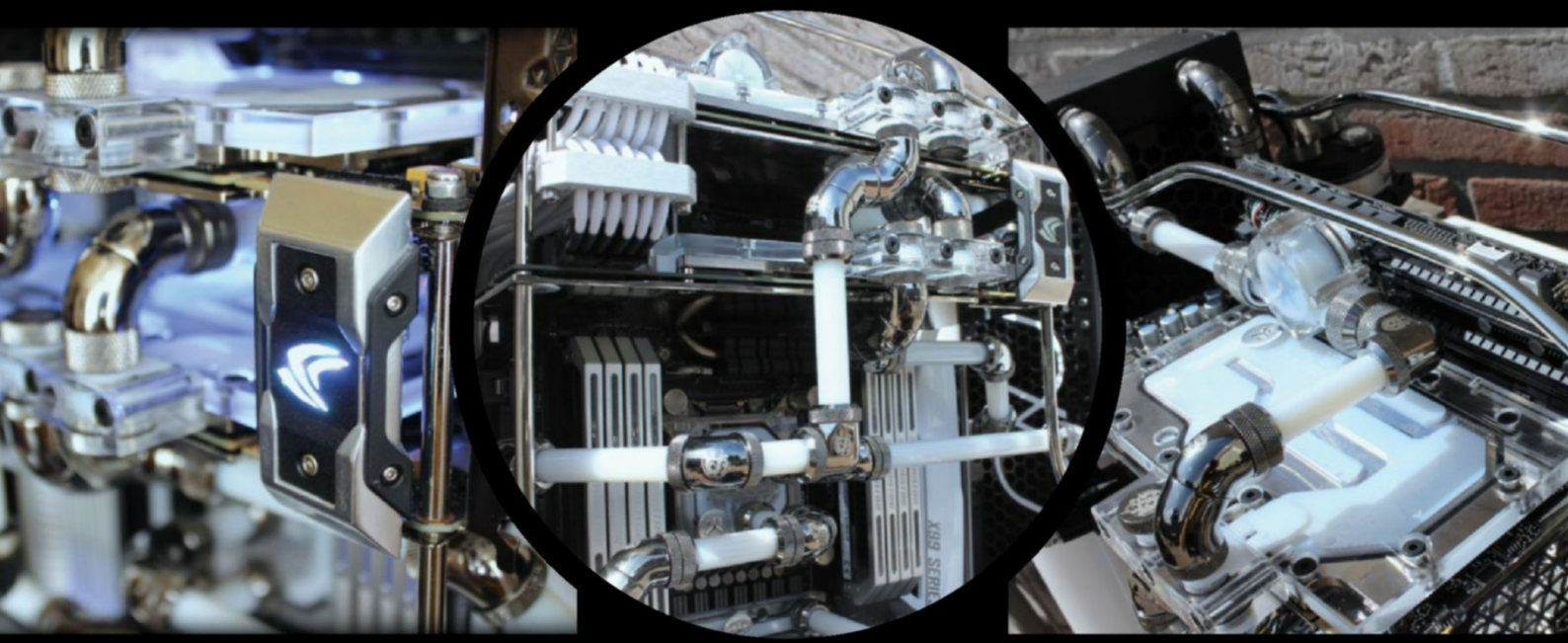
Motherboard Asus X99 Deluxe

PSU Corsair HX1000i

Storage 2 x Corsair Force LX 512GB (modded into one RAID 0 drive)

Case Scratch build

Cooling Custom water-cooling loop: Bitspower fittings and pump/res combos; EKWB water blocks, radiators and coolant; CoolForce PETG; Parvum custom laser-cut aluminium and Plexiglas frame



CPC: What materials did you use?
Peter: The frame is made from two parts, each with one layer of 3mm clear acrylic sandwiched by two layers of 3mm aluminium. I needed this 9mm thickness to enable me to use Bitspower fill ports, which have 10mm connectors.

I bolted the two three-layer parts together with little aluminium blocks to give the structure as much stability as possible.

Meanwhile, the fan guards were CNC-milled out of aluminium, and reused from Raz3r D3sk without the acrylic inlaying. Then there's the aluminium CNC-milled Corsair Dominator Platinum-style cable clips that Scott Bruins and I designed especially for this project, which will soon be manufactured by CoolForce/Nanoxia for the masses. The other materials I used were basically 3M Dual Lock, electrical tape, some glue, and lots of stainless steel bolts and nuts.

CPC: What tools and/or machinery did you use?
Peter: The frame was CNC-milled and laser-cut by Parvum Systems, but all the other work was done by hand with a drill, countersink drill, tap, jigsaw, file, soldering iron, iron saw, 12/10mm deburrer and various grit levels of sandpaper. It would even be possible to build the frame by hand, but since I have a good relationship with Justin and Shaun at Parvum, we decided to cooperate on this project too.

CPC: How long did the build process take?
Peter: I never really keep track of the total number of hours taken to finish a project, as a lot of time also goes into preparation, design, emails, website and social media. It took me nine months in total, but on some days I worked on it for just five minutes, while on other days I worked on it for a few hours. The real modding pretty much only happens at the weekends, as I don't have much time in the week because of my work and family. I'm a kitchen table modder, so I also need the time to clean up after myself after every session.

CPC: What did you learn from the build process?
Peter: You need a big work space, lots of fittings and a lot of time for a project such as L3pipe. I like to keep my work area clean and ordered, and if you spread this amount of bolts, nuts, fittings and pipes everywhere, you'll lose a lot of time. Also, when you're in the process of drilling holes, filing and sanding – the rough work – try to do it all before starting with the hardware and the water-cooling loop. If you need to drill a hole when you've already started on the loop, then it ends up taking a lot of time, as you need to clean up very carefully afterwards.

CPC: Are you happy with the end result?
Peter: I'm very happy with the end result! I didn't have a single leak when I filled the water-cooling loop for the first time, and even the hardware worked without a problem at first boot. Those types of moments make you grin for a week! Of course, a little voice in my head kept screaming 'CoolForce Acid Green, just try it!' and I did, along with Mayhems Aurora 2 Blue. These different coolant colours completely changed the look of the build, and changing them was a lot of fun to see and do, although it took me two days to clean the Aurora 2 out of the system. Huge thanks go to Corsair, Nvidia, Intel, Asus, EKWB, Bitspower, Highflow and Parvum Systems! CPC

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to **www.bit-tech.net** and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.

Mayhems coolant and dyes

VALUE £50 inc VAT / **MANUFACTURER** www.mayhems.co.uk

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors.

As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

DOWNLOAD FROM WWW.ASUS.COM/CAMPAIGN/REALBENCH

CUSTOM PC REALBENCH 2015

in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than more CPU cores.

Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake video encoding takes full advantage of many CPU cores, pushing them to 100 per cent load.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2,400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. CPC

SHOUT OUTS!

Unsurprisingly, 8Pack is still king of the leaderboard, with his 5.5GHz Core i7-5960X, but we've had plenty of changes in the top 10 this month. Chris_Waddle has moved up to number 3 from number 11 after upgrading to a 5960X rig, while dax, mboogie and dubai1 have entered the table at number 8,9 and 10.

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

CUSTOM PC REALBENCH 2015 LEADERBOARD

RANK	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	275,683	240.9%	8pack	Asus Rampage V Extreme	Intel Core i7-5960X	5.5GHz	16GB Kingston 3000MHz	Nvidia GeForce GTX Titan X
2	233,375	203.9%	ian.parry3	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	32GB G.Skill 3200MHz	Nvidia GeForce GTX Titan X
3	219,638	191.9%	Chris_Waddle	Asus X99 Deluxe	Intel Core i7-5960X	4.6GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX Titan X
4	219,415	191.7%	Luke@DinoPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	16GB Corsair 3276MHz	Nvidia GeForce GTX Titan X
5	206,723	180.6%	stuart	Asus Rampage V Extreme	Intel Core i7-5960X	4.41GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 780 Ti
6	201,446	176.0%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.3GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX Titan X
7	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2400MHz	AMD Radeon R9 200 Series
8	189,230	165.3%	shadowsrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980
9	185,219	161.8%	dax	Asus Rampage V Extreme	Intel Core i7-5960X	3.97GHz	32GB Corsair 2448MHz	Nvidia GeForce GTX 980
10	179,386	156.7%	mboogie	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Crucial 2133MHz	Nvidia GeForce GTX 980
11	176162	153.9%	dubai1	Asus X99-Pro/USB 3.1	Intel Core i7-5960X	4.4GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980 Ti
12	172,828	151%	mdottwo	Asus Rampage V Extreme	Intel Core i7-5820K	4.4GHz	16GB G.Skill 2766MHz	AMD Radeon R9 200 Series
13	169,721	148.3%	mark.gee93	Asus Rampage V Extreme	Intel Core i7-5930K	Not reported	12GB Corsair 3134MHz	Nvidia GeForce GTX 980 Ti
14	167,332	146.2%	grozzie	ASRock X99M Killer	Intel Core i7-5930K	4.48GHz	32GB Kingston 3071MHz	AMD Radeon R9 200 Series
15	167,002	145.9%	maliepaard.chris	MSI X99S SLI Plus	Intel Core i7-5820K	4.49GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 980 Ti
16	165,512	144.6%	Penfold	Asus X99-Deluxe	Intel Core i7-5820K	4.5GHz	32GB Corsair 2333MHz	AMD Radeon R9 200 Series
17	163,650	143%	shaunhanson	MSI X99S SLI Plus	Intel Core i7-5820K	Not reported	16GB Corsair 2133MHz	Nvidia GeForce GTX 980
18	163,400	142.7%	andy	MSI X99S Gaming 7	Intel Core i7-5820K	4.4GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX 980
19	163,065	142.5%	viperz	Asus X99-Deluxe	Intel Core i7-5820K	4.48GHz	16GB Corsair 2400MHz	Nvidia GeForce GTX 970
20	160,855	140.5%	imre_grozner	ASRock X99M Killer	Intel Core i7-5930K	4.19GHz	32GB Kingston 2666MHz	AMD Radeon R9 200 Series

Folding@Home

Join our folding team and help medical research

MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE
dbmitch84	40000
Capt-Camm-Nett	50000
Mr.Eke	50000
HiroMilo	60000
whiskeyecho	60000
Alee4177	100000
FREE_WORLD	100000
grozzie	100000
LEACHIE007	100000
centurion	200000
nbowling	200000
Bleakknave	300000
Chrisz0rz	400000
Kentara	400000
mort6dav3	500000
TheRepublic ofKirkup	500000
TimmyH	500000

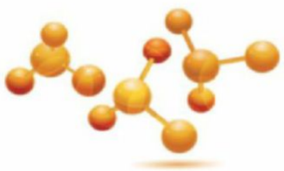
USERNAME	POINTS MILESTONE
GarethFlatlands	600000
smiler	700000
Glyn_Mason	800000
GJBriggs	900000
Quozzbat	900000
daza17	1000000
FurstyFerret	1000000
Just_G	1000000
scoobyzilla	1000000
PURE	2000000
QuasarGreg	2000000
ssjandu	2000000
StuManchu	2000000
Ganey	3000000
kornvdd	3000000
Laguna2013	3000000
RaistlinRTCW	3000000
Simbouncer	3000000

USERNAME	POINTS MILESTONE
b1ll55t34m	4000000
bigrew	4000000
Clotten	4000000
RDL_Mobile	5000000
SMauri	5000000
awstcomputers	6000000
techknowledgey	6000000
andboo1	8000000
Liam266	8000000
MarkVarley	8000000
SirBenjaminNunn	8000000
Werewolf_Legs	9000000
Allan_Smith	10000000
Brentwood-Computers.com	10000000
Mem	10000000
adbygrave	20000000
Neku	20000000

USERNAME	POINTS MILESTONE
Trunkey	20000000
daxchaos	30000000
Portchylad	40000000
BeezaBob	60000000
Maglor	60000000
Sean_Hayes	80000000
mmorr	90000000
Dickie	100000000
Desertbaker	200000000
The_M2B	300000000
Cmaxx	60000000
Dickie	90000000
Roveel	100000000
Laguna2012	200000000
TheFlipside	200000000
HHComputers	400000000
piers_newbold	600000000

WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from **http://folding.stanford.edu** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers on the **www.bit-tech.net** forums.



TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Nelio	2,425,474,243	144,184
2	DocJonz	1,422,264,435	180,316
3	coolamasta	792,037,691	173,327
4	Scorpuk	685,216,399	28,576
5	piers_newbold	648,853,141	45,093
6	StreetSam	570,985,851	90,228
7	HHComputers	497,929,850	23,345
8	PC_Rich	470,049,222	78,818
9	Dave_Goodchild	465,588,714	119,689
10	johnim	432,683,664	81,408
11	Slavcho	364,473,460	34,702
12	Lordsoth	339,634,603	95,857
13	The_M2B	311,739,876	59,106
14	phoenicis	250,044,587	95,660
15	Laguna2012	245,158,456	21,923
16	Desertbaker	215,430,216	18,090
17	Wallace	212,477,027	6,204
18	zz9pzza	211,014,628	15,794
19	TheFlipside	204,942,361	22,183
20	KevinWright	179,478,373	30,214

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	HHComputers	4,387,690	497,929,850
2	DocJonz	2,469,138	1,422,264,435
3	Scorpuk	1,338,446	685,216,399
4	Lordsoth	1,283,175	339,634,603
5	piers_newbold	1,253,495	648,853,141
6	Nelio	1,092,476	2,425,474,243
7	Laguna2012	982,228	245,158,456
8	Dickie	740,292	120,939,439
9	PC_Rich	735,911	470,049,222
10	Slavcho	730,556	364,473,460
11	Desertbaker	644,604	215,430,216
12	coolamasta	636,596	792,037,691
13	apeman556	584,052	174,293,695
14	The_M2B	549,270	311,739,876
15	Roveel	476,038	126,227,585
16	johnim	462,142	432,683,664
17	KevinWright	439,505	179,478,373
18	daxchaos	427,318	31,218,116
19	Andy_J	336,026	48,960,598
20	Maglor	309,799	60,037,704

JAMES GORBOLD / HARDWARE ACCELERATED

THE SKYLAKE SUPPLY DILEMMA

A classic supply and demand problem could make Haswell-E a realistic alternative to Skylake, argues James Gorbold

For months now, the industry has been gearing up for the launch of Intel's Skylake platform. Without exception, all the reviews in the press were positive, and the new chipset Z170 was well received too, as it added four extra dedicated PCI-E 3 lanes for high-speed SSDs. Commercially, however, Skylake hasn't been smooth sailing.

As with any launch of a new component, availability at launch is always expected to be tight, with the most influential resellers and PC manufacturers getting the lion's share of allocation. However, for Skylake, supply wasn't just tight, but incredibly constrained, with many smaller resellers not getting any stock at all. I know this, because at Scan we could see many of our smaller competitors trying to buy Skylake kit from us. Since then, the situation has gone from bad to worse. In the first few weeks, Skylake CPUs arrived in batches of 50 or so, but right now we're lucky to receive more than ten CPUs per batch.

The limited supply of Skylake CPUs has had a big effect on the market because, as any economics student could tell you, when supply of a product is limited and demand is high, the price goes up. In fact, Skylake pricing started going up even before its public launch. So, despite the Skylake Core i7-6700K having the same official US price of $339 as the Devil's Canyon Core i7-4790K, the market price is very different. For example, you could pick up a 4790K for £249 inc VAT, while the 6700K price has inflated to £359 inc VAT. However, even at this much (artificially) higher price, demand for Skylake is very high, leading to resellers and PC manufacturers fighting over stock.

As any economics student could tell you, when supply is limited and demand is high, the price goes up

The end result is that, with a typical £100 delta between a Devil's Canyon and a Skylake system, the former, older tech is still proving very popular, accounting for around 50 per cent of CPU sales. Fortunately, for now at least, there's a good supply of Haswell Refresh CPUs and Z97 motherboards in the channel, although I wouldn't like to work at a motherboard manufacturer and have to judge how many of each type of board we should manufacture and ship at the moment.

After all, at some point in the next few months, Skylake supply will start to free-flow, causing its price to fall and make Devil's Canyon less desirable.

The other effect has been a shot in the arm for sales of the 6-core Core i7-5820K. Typically this CPU, plus motherboard and RAM was around £250 more expensive than a Devils' Canyon system, prompting most gamers to opt for the cheaper quad-core platform. However, with the price inflation of Skylake CPUs, the delta between the 6700K and 5820K is much closer, at just £100. And while £100 is still a big step up, that 5820K system would give you two more CPU cores, 16GB of quad-channel DDR4 compared with 8GB of dual-channel DDR4 and more PCI-E lanes too.

With the availability of Skylake not likely to enter free-flow until well into 2016, this year's traditional Christmas upgrade cycle is going to be interesting for PC enthusiasts, with three decent choices of Intel platforms competing for your cash. Do you opt for a cheap and fast Devil's Canyon PC, a slightly faster, more future-proofed Skylake PC (if you can get hold of a CPU) or spend just a little more and get a monster 5820K? EPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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